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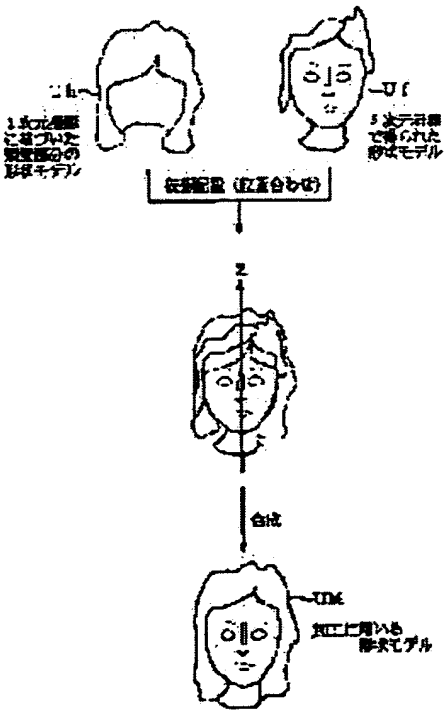
(54) **MODELING SYSTEM**



(57)Abstract:
PROBLEM TO BE SOLVED: To model the shape of a body having a part which is hardly measured in three dimensions by synthesizing three-dimensional shape data with plural two-dimensional shape data of the body.
SOLUTION: A generated shape model Uh for a head hair part and a shape model Uf for a customer obtained through three-dimensional measurement are positioned and arranged in a three-dimensional space and set operation for finding the sum of the both is performed to synthesizing one shape model UM. At this time, the shape model Uh for the head hair part is handled as an auxiliary model for restoring deficiencies of the measurement and when superposition is contradictory, data corrections are made while priority is given to the shape model Uf in principle. The shape model UM which is thus obtained is used to perform processing and then even if data of part of the head hair is not obtained by the three-dimensional measurement, a face model having the outline of the head hair correctly reproduced can be generated.

[JP,11-328444,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] The modeling system characterized by having a three-dimension measurement means to measure an objective three-dimension configuration and to output the 1st configuration data, a means to photo said body from a different location and to obtain two or more two-dimensional images, a means to generate the 2nd configuration data based on said two or more two-dimensional images, and a means to compound said 1st and 2nd configuration data.

[Claim 2] Said three-dimension measurement means is a modeling system according to claim 1 which projects a reference beam on a body, receives the reflected light, and measures a configuration based on the light-receiving output.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is used for creation of the model of a body head, concerning the modeling system which generates the geometric model of the body which exists.
[0002]
[Description of the Prior Art] The non-contact type three-dimension metering device (range finder) of a portable mold is commercialized, and it is used for the visual recognition of the data input to CG system or a CAD system, a somatometry, and a robot etc. As the non-contact measurement approach, although slit light projection (optical cutting method) is common, otherwise, pattern light projection, the stereo ** method, the interference fringe method, etc. are learned.
[0003] On the other hand, a kind of automatic vending machine which creates a user's photograph-of-his-face seal on that spot is collecting popularity. A user throws in the coin for a tariff, and he makes a favorite pose by Saki of a camera, looking at a monitor image. And if predetermined actuation is performed, the sheet with which a fixed number of seals were located in a line will be created, and it will be discharged by output port.
[0004]
[Problem(s) to be Solved by the Invention] According to the above-mentioned three-dimension metering device, the configuration of the various bodies which contain the body by handiness comparable as taking a photograph can be data-ized. Since it is a non-contact type, even if it is the case where the body is measured, a measurement candidate does not sense troublesomeness.
[0005] However, in especially the optical three-dimension measurement that projects reference beams, such as slit light, the configuration of the hair part of the body may be correctly immeasurable. That is, with black hair, since the reflection factor of a reference beam is low, the light income of a range finder becomes inadequate and a measurement value tends to be missing. Moreover, the effect of a hair style is also large. For this reason, on the occasion of creation of the geometric model of a body head, there was a problem of a hair part not having been reproduced or becoming imperfect.
[0006] This invention aims at three-dimension measurement realizing modeling of the configuration of a body with a difficult part.
[0007]
[Means for Solving the Problem] In this invention, the part of an objective specific color is modeled in simple using two or more two-dimensional photography information that whenever [to a body / angle-of-coverage] differ. For example, from each of two or more two-dimensional images which photoed the body from a mutually different location and were obtained, the field which fills the setups of color information is extracted and the geometric model of the part which fills the setups in a body is generated by calculating the coordinate in the virtual space of the location on the body corresponding to each profile of two or more extracted fields. Two or more two-dimensional images which photoed the body in more detail from the location where they differ mutually as a look crosses at one point in, and were obtained Image size is arranged so that an objective representative fraction may be in agreement, it arranges to a virtual space so that

each core may be in agreement and a mutual arrangement angular relation-ship may correspond to the relation of the sense of a look and a field angle, and the relative-position relation of the profile of the field which fills the setups of the color information extracted from the 2-dimensional each image is calculated. The core of an image is a pixel location corresponding to the look at the time of photography (light-receiving shaft).

[0008] A geometric model with high fidelity is obtained by using together modeling based on the three-dimension measurement information in which modeling based on two-dimensional photography information and modeling highly precise than it are possible.

[0009] The modeling system of invention of claim 1 has a three-dimension measurement means to measure an objective three-dimension configuration and to output the 1st configuration data, a means to photo said body from a different location and to obtain two or more two-dimensional images, a means to generate the 2nd configuration data based on said two or more two-dimensional images, and a means to compound said 1st and 2nd configuration data. The hardware containing the processor for a general purpose or image processings and suitable software can constitute a means to generate configuration data, and a means to compound.

[0010] In the modeling system of invention of claim 2, said three-dimension measurement means projects a reference beam on a body, receives the reflected light, and measures a configuration based on the light-receiving output.

[0011]

[Embodiment of the Invention] Drawing 1 is the external view of the three-dimensional-model listing device 1 concerning this invention. The three-dimensional-model listing device 1 measures a body configuration, has the function to process a material on that spot based on the measurement data, and is used as an automatic vending machine of the accessories article which modeled a user's face. The goods created are the stereos with which the model of the face (the hair is included) projected from the plate surface of a predetermined configuration (for example, square). It is also possible to add a specific boom-hoisting pattern to a plate surface (a part for a background). If the suitable metallic ornaments for such goods are attached, it will become accessories, such as a pendant, a broach, and a key holder. Metallic ornaments may be beforehand attached in a material.

[0012] The floodlighting aperture 12 and the light-receiving apertures 14, 15A, and 15B are formed in the front face of the almost life-size Johan section of a case 10 with the display 16 for a user to check a pause. Optical three-dimension measurement is performed using the floodlighting aperture 12 and the light-receiving aperture 14. The light-receiving aperture 14 is used also for the two-dimensional color photography of the direction of a transverse plane. The light-receiving apertures 15A and 15B are used for the two-dimensional color photography of the direction of slant peculiar to this invention. The bottom half section of a case 10 is jutted out over the front side rather than the Johan section, and the top face serves as a control panel 18. The output port 20 of goods is established in the front face of the bottom half section.

[0013] Drawing 2 is the mimetic diagram of the busy condition of the three-dimensional-model listing device 1. The blue background sheet 2 is arranged ahead of the three-dimensional-model listing device 1. A user 3 stands toward the three-dimensional-model listing device 1, using the background sheet 2 as the back, and throws in the coin for a tariff. If a user 3 performs start actuation after that, the three-dimensional-model listing device 1 will display the three-dimension geometric model (for example, surface model) which shows a measurement result while measuring the configuration of the body which exists within the limits of [fixed] a

transverse plane. And if a user 3 performs confirmation operation, the three-dimensional-model listing device 1 will start three-dimension processing according to a measurement result. Goods are completed by the time amount for about several minutes. A user 3 takes out goods from output port 20.

[0014] Drawing 3 is the top view of a control panel 18. The input port 185 of a start button 181, a confirmation button 182, Cancel button 183, a joy stick 184, and a coin is established in the control panel 18. A start button 181 is a start actuation means, and a confirmation button 182 is a confirmation operation means. A joy stick 184 is used for modification directions of the composition of a model. In response to the Pan actuation leaned to right and left, the tilt actuation leaned up and down, and roll actuation of rotating a knob, rotation processing of a three-dimension geometric model is performed, and a processing result is displayed on serial. Moreover, Cancel button 183 is an actuation means for directing re-measurement, when the three-dimension geometric model as which the user 3 was displayed is not pleasing. However, the count of effective is set to Cancel button 183, and re-measurement cannot be directed without any restriction.

[0015] Drawing 4 is the functional block diagram of the three-dimensional-model listing device 1. The three-dimensional-model listing device 1 consists of modeling system 1A which generates the three-dimension geometric model of model size, and processing system 1B which actualizes a three-dimension geometric model.

[0016] Modeling system 1A contains the photography system 30 which changes into digital data appearance information of the user 3 who is an original body (data-izing). The photography system 30 consists of the three-dimension metering device 34 which data-izes configuration information by slit light projection, a total of three two-dimensional photography equipments (the main camera 36, auxiliary cameras 37L and 37R) which data-ize color information, and a controller 38. In addition, it may replace with slit light projection and other optical technique may be used for three-dimension measurement. The color picture data DC2 and DC3 which are the photography information on the color picture data DC 1 which are the photography information on the configuration data DS which are the measurement information by the three-dimension metering device 34, and the main camera 36, and each auxiliary cameras 37L and 37R are inputted into a data processor 40. Since the relative relation of the camera coordinate of three-dimension measurement and two-dimensional photography is known, it is easy to carry out alignment of the three-dimension geometric model based on the configuration data DS and the two-dimensional photography image. The data processor 40 is equipped with the image-processing circuit which is not illustrated, and performs various kinds of data processing including data correction peculiar to this invention. That is, a data processor 40 is a means to generate the 2nd configuration data of this invention, and is also a means to compound the 1st and 2nd configuration data. The controller 42 of a data processor 40 also bears overall control of the three-dimensional-model listing device 1, and gives the suitable directions for the controller 38 of the photography system 30, and the controller 76 of processing system 1B. A display 16 and the actuation input system 80 are connected to this controller 42. The actuation input system 80 consists of an above-mentioned control panel 18 and an above-mentioned tariff receipt device.

[0017] On the other hand, processing system 1B is equipped with the processing equipment 72 which cuts ingredients, such as a resin block, the ingredient feeder 74 which performs supply in the processing location of an ingredient, and conveyance to the output port 20 of a workpiece,

the controller 76, and the output port sensor 78. The detecting signal of the output port sensor 78 is inputted into a controller 42. In addition, a controller 42 may be made to take charge of control of the photography system 30 and processing system 1B, and the circuitry which omitted the controller 38 and the controller 76 may be adopted.

[0018] Drawing 5 is the perspective view showing an example of the device configuration of processing system 1B. The ingredient feeder 74 has the stock section 210 which contains the ingredient of a total of eight sorts of configurations. Storage space is established in the both sides of the straight-line-like migration way 212, and the elevator 220 is arranged four pieces at a time along the migration way 212 in the storage space of each **. Two or more ingredients of the same class are accumulated on each elevator 220, and vertical migration control of an elevator 220 is performed so that the best ingredient may be located in predetermined height. If one kind of ingredient suitable for the model which it is going to create is specified, the specified ingredient will extrude as a work piece 216, and will be sent out from storage space with a rod 218 on the migration way 212. And the work piece 216 on the migration way 212 is sent into the table 200 of processing equipment 72 with the migration rod 214 with a chuck.

[0019] In a table 200, a work piece 216 is fixed with two stoppers 202 and clamp fixtures 204. And it is cut with the cutters 208, such as an end mill attached in the upper and lower sides, right and left, and order at the movable revolving shaft 206.

[0020] After three-dimension processing is completed, a work piece 216 is pinched by the chuck at the tip of the migration rod 214, is carried to the edge by the side of discharge of the migration way 212, and is sent into an exhaust port 222. It may not be based on the migration rod 214, but a work piece 216 may be moved to an exhaust port 222 from a table 200 in a sliding way format.

[0021] The device configuration of processing system 1B is not restricted to instantiation. For example, if an elevator is horizontally arranged [ingredient / of the same class] at the end of the array direction on each multistage shelf and an ingredient is extruded in an elevator from a shelf, the number of elevators can be reduced. You may also carry a work piece to a stowed position -> processing location -> discharge location with an arm robot. It is also possible to replace with cutting and to create a model by technique, such as the laminating molding method (for the Mitsuzo form method to be included), laser processing (thermoforming), and molding processings (pressurization etc.). Moreover, about an ingredient configuration, a user 3 may enable it to choose a favorite appearance, and may be made to make automatic selection of that to which floor to floor time becomes the shortest from two or more sorts of ingredients which made the model of a standard face beforehand.

[0022] In the three-dimensional-model listing device 1 of the above configuration, in order to create the natural face model by which the profile of the hair section was reproduced correctly, the data correction which transforms automatically the three-dimension geometric model obtained by three-dimension measurement is made by the data processor 40. That is, the configuration of a data lack part where the effective measurement value of the hair sections is not obtained is restored based on two or more two-dimensional images.

[0023] Drawing 6 is the mimetic diagram of camera arrangement of two-dimensional photography. XYZ system of coordinates are set as the space which stands as for a user 3. To a longitudinal direction, a Y-axis is taken to a cross direction and the Z-axis is taken for the X-axis in the vertical direction. A camera station is defined according to a standard actuation posture, and the Z-axis is in agreement with the medial axis of a user's 3 head in drawing 6 .

[0024] The main camera 36 and the auxiliary cameras 37A and 37B are arranged at a radial at

the circumference of the Z-axis, and each look (light-receiving shaft) crosses at one on the Z-axis (for example, origin of coordinates). The look of the main camera 36 is in agreement with a Y-axis. theta 2 is [whenever / angle-of-inclination / of the look of auxiliary camera 37L to the main camera 36 / whenever / angle-of-inclination / of the look of theta 1 and auxiliary camera 37R] the same. However, it is not necessary to necessarily make theta1 and theta2 the same whenever [angle-of-inclination].

[0025] In such camera arrangement, a user 3 is photoed from the front, auxiliary camera 37L photos a user 3 from the method of the diagonal left, and, as for the main camera 36, auxiliary camera 37R photos a user 3 from the method of the diagonal right. In addition, it is good also as a value which may lean each look to a horizontal plane and is different for every camera in whenever [angle-of-inclination].

[0026] Drawing 7 and drawing 8 are drawings for explaining the point of the modeling based on a two-dimensional image. A data processor 40 extracts first the hair part (hair image) h to which the slash was given by drawing 7 from the two-dimensional images G1 and G2 and G3 which the color picture data DC1, DC2, and DC3 express, and extracts the profile of the hair image h further. The point of an extract of the hair image h is as follows. ** Divide a two-dimensional image into the field of a same color phase by clustering in a specific color space (for example, L* a* b* color space). ** the result -- receiving -- labeling -- carrying out -- a same color phase -- and extract the continuous field. ** Are in contact with the field of the color (blue) of the background sheet 2, and let the field of a setting hue (for example, black and the color near it) be the hair image h.

[0027] Then, the relative relation of the three dimension of the location on the body (user 3) corresponding to each profile of the 2-dimensional each images G1 and G2 and the hair image h extracted from G3 is specified. That is, the coordinate of the profile of the hair image h when setting the hair image h extracted from the two-dimensional images G1 and G2, G3, or them by photography conditions, and having arranged to three-dimension space virtually is calculated. While making in agreement the core of the image shown with a notation (+) by drawing 7 on the occasion of the arrangement to three-dimension space and making a mutual arrangement angular relation-ship correspond to the relation between the look at the time of photography, and the sense of a field angle, it expands or reduces if needed so that an objective representative fraction may be in agreement. The core of an image is a pixel location corresponding to the look at the time of photography. With this operation gestalt, since the look at the time of photography is in the same flat surface, the 2-dimensional each images G1 and G2 and G3 are made to meet the Z-axis, and if only include angles theta1 and theta2 lean and arrange the two-dimensional image G2 and G3 to the two-dimensional image G1, the sense of a field angle will gather. If the photography scale factor is set up identically, there will be no need for expansion/contraction. In addition, since the relative-position relation of the hair image h should just be known, it is not necessary to make the hair image h into the magnitude which ****s on a body in this phase. Drawing 7 (B) is the top view showing the physical relationship of the profile of the hair image h on one flat surface perpendicular to the Z-axis. When the rim of the hair is modeled, especially the location of two points of both ends is important among the locations of X shaft orientations of the profile in the attention location of Z shaft orientations.

[0028] Next, the contour line Lh of an epilogue and the hair is computed for the intersection when cutting in respect of being perpendicular to the profile and the Z-axis of a total of three hair images h by which virtual arrangement was carried out (level surface) by the B spline curve. And

let the field (surface) which connected the contour line Lh in two or more locations of Z shaft orientations by smoothing be the geometric model Uh of a hair part.
[0029] Drawing 9 is the mimetic diagram of composition of a geometric model. Alignment is made three-dimension space, the geometric model Uh of the hair part created in the above-mentioned way and a user's 3 geometric model Uf obtained by three-dimension measurement are arranged to it, the set operation which asks for both sum is performed, and it compounds to one geometric model UM. At this time, when it treats as an auxiliary model which restores lack of measurement and conflict of a lap arises, the geometric model Uh of a hair part gives priority to a geometric model Uf in principle, and adds data correction.
[0030] Thus, even if some data of the hair were not obtained in three-dimension measurement by processing it using the obtained geometric model UM, the face model which reproduced the outline of the hair correctly can be created.
[0031] Hereafter, a flow chart explains actuation of the three-dimensional-model listing device 1. Drawing 10 is the Maine flow chart which shows actuation of an outline. After a power source is switched on, in the waiting period which waits for actuation by the user, two-dimensional photography and the display of a photography result are repeated (#10, #12, #14). Moreover, a guidance message is displayed periodically. If a tariff is injected and a start button 181 is pushed, while performing two-dimensional photography anew, three-dimension measurement will be performed (#16, #18). Predetermined data processing is performed (#20) and the obtained three-dimension geometric model is displayed (#22). At this time, appearance is raised with the application of the well-known graphic technique of attaching a shadow. And it waits for directions actuation. However, the latency time is limited, and if it passes over the time limit, it will be considered that it is that to which confirmation operation was performed.
[0032] If a joy stick 184 is operated, a three-dimension geometric model will be rotated according to actuation as mentioned above, and it will display (#24, #38). If Cancel button 183 is pushed, it will return to actuation of a waiting period (#40, #10). However, re-measurement will be performed, if a user does not need to inject a tariff anew and pushes a start button 181 in this case.
[0033] A push on a confirmation button 182 generates the data for processing control with reference to a processing condition database based on a three-dimension geometric model (#28). (#26) An ingredient is processed (#30). After processing finishes, goods are discharged (#32), and it checks that goods have been taken out by the output port sensor 78, and returns to standby actuation (#34, #10).
[0034] Drawing 11 is a flow chart which shows the contents of data processing of drawing 10 . By this routine, the next processing including the data correction which restores the configuration of the hair as mentioned above and compaction of floor to floor time, or compression of the depth direction for intentional flattening on a design is performed.
[0035] While performing data smoothing and removing the abnormality data based on a noise, it avoids that excess reappears to fine irregularity (#200). Re-sampling processing is performed (#210). This is processing changed into the data which aligned by the lattice point of spacing, such as having carried out parallel projection from a certain direction, in order to make the right pair of the input data carry out in the processing direction, when the face has turned to slant. For example, when the bottom of the lug of people's face becomes shade and cannot measure, after wearing a face upward and carrying out three-dimension measurement, data are convertible so that the face which turned to the usual transverse plane may be expressed. When there is no

measure point in the location where the lattice point was projected, the measurement value of the perimeter performs a linearity complement. At this time, it becomes the vertical upper part at the time of the projected direction processing it, and each lattice point has data of height. Moreover, even when input data is based on a perspective projection, input data can be changed into parallel projection data by this processing.

[0036] A fine deficit part without data is complemented (#220). As the complement technique, various technique, such as a linearity complement and weighting ****, is applicable. For example, all the parts into which data are missing are replaced with a fixed value (simple complement). As the fixed value, the average of the set point, the minimum height, and the periphery location of a face can be considered. When the deficit section is completely surrounded in the effective-data part, a linearity complement is carried out from surrounding data. Thereby, the deficit part in the face (for example, black eyebrows) is restored.

[0037] The geometric model Uh of a hair part is created in the way mentioned above, and it compounds with the geometric model Uf based on the observation data of a three dimension. That is, the partial correction which adds the hair is made to a geometric model Uf (#230). Stripes-like boom hoisting is added to a hair part in this phase, texture can be raised or emphasis which heaps up particular parts, such as an eye, an iris-of-the-eye part, eyebrows, a lip, and a cheek, a little can be performed.

[0038] After obtaining the geometric model UM faithful to an object configuration by each above processing, height compression processing is performed and the dimension of a three-dimension geometric model is contracted in the depth direction (#240). If the difference of elevation of the depth direction becomes small, floor to floor time will become short. Moreover, for the application of a pendant or a medal, a superficial model is suitable. To compression, both of the technique, uniform compression and un-uniform compression, can be applied, and it can also use properly for every part to it.

[0039] A part for the background of the three-dimension geometric models is detected (#250). This is pretreatment for correcting a part for a background. If a user's tooth back is considered as the blue back with the background sheet 3, a part for a background is certainly [easily and] detectable with color distinction of a two-dimensional image.

[0040] Background conversion transposed to other data about a part for a background is performed (#260). For example, since depth is extremely deep, a part for a background is changed into data with shallow depth in order to shorten floor to floor time. The solid side data which express patterns and geometric patterns, such as flowering trees and shrubs, also by flat-surface data are sufficient as the data to replace.

[0041] Size adjustment in which a full-scale three-dimension geometric model is fitted to goods size is performed (#270). Moreover, resolution conversion in which the amount of data is fitted to the precision of processing equipment 72 is performed (#280). Although this processing projects the mesh of predetermined grid width of face and it re-samples in the lattice point, the direction to project is being fixed in the direction of a vertical at the time of processing. As the point of resolution conversion (the number conversion of data), first, the pitch between points and ** KUTORU variation define the configuration point group of the geometric model for processing, and the pitch range between points corresponding to ** KUTORU variation is read from the property data table memorized beforehand, and is set up. That is, data are thinned out, a pitch is enlarged, or data are interpolated and a pitch is made small. What is necessary is only just to cull out, when the resolution of measurement is large enough. If the resolution conversion

function is prepared, since the resolution of the three-dimension metering device 34 will not be limited, the use gestalt of exchanging a measurement means according to an application will be permitted.

[0042] Alignment to which the parallel displacement of the zero of a coordinate is carried out so that the criteria location of a three-dimension geometric model may suit the last in the criteria location of processing is performed (#290). In addition, when using the ingredient with which predetermined irregularity was made above beforehand on the occasion of processing, in the processing data generation processing (#28 of drawing 10) in response to confirmation operation, the amount of cutting is computed by comparing the three-dimension geometric model obtained by the above processing with the irregularity made.

[0043] Drawing 12 is the flow chart of the partial correction subroutine of drawing 11 . As drawing 7 explained, the two-dimensional images G1 and G2 and G3 which are the photography information on three directions first are incorporated (#301), and it is L* a* b*. Field division in a color space is performed (#302). The field of a setting hue is distinguished from the hair image h (#303), and the profile is extracted (#304). It asks for the high line Lh, such as having corresponded to the profile of the hair image h, (#305), a contour line Lh is connected, and the geometric model Uh of the hair is generated (#306). And the geometric model Uh of the hair based on a two-dimensional image and the geometric model Uf based on three-dimension measurement are compounded (#307).

[0044] the above operation gestalt -- setting -- the scalp from three-dimension measurement data -- the scalp the configuration of a field was presumed to be and the configuration created from the two-dimensional image was presumed to be in the following ways with reference to the result -- it is desirable to make it not become inside a field.

[0045] drawing 13 -- the scalp -- the mimetic diagram of presumption of a field configuration, and drawing 14 -- the scalp -- it is the flow chart which shows an example of the creation point of a field geometric model. The profile of a user's 3 head is obtained from the geometric model Uf which consists of a face field Uf1 and a hair field Uf2 (#3051). the middle point (black dot of drawing 13) between the points with which two or more suitable points on a profile (white round head of drawing 13) were chosen and which were adjoined of the selected point or them -- a control point -- carrying out -- a spline curve -- the scalp -- a field configuration is approximated (#3052, #3053). The approximation curve which passes along the inside of the profile of the hair is obtained by making the point on a profile into a control point about the face field Uf1, and making the middle point into a control point about the hair field Uf2. two or more approximation curves in the same way -- asking -- between them -- surface -- interpolating -- the scalp -- the field geometric model Us is obtained (#3054).

[0046] Although the three-dimensional-model listing device 1 supposing the use as an automatic vending machine was illustrated with the above-mentioned operation gestalt, it does not ask whether data processing concerning this invention is whether model creation is onerous and onerous. Not only contraction size but actual size or expansion size is sufficient as the size of a model. the geometric model UM obtained by composition with the geometric model Uh based on two or more two-dimensional images and the geometric model Uf based on three-dimension measurement data can be used for an application at versatility other than model creation, such as a display and animation creation.

[0047]

[Effect of the Invention] According to invention of claim 1 or claim 2, three-dimension

measurement can realize modeling of the configuration of a body with a difficult part like the hair configuration of the body.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention is used for creation of the model of a body head, concerning the modeling system which generates the geometric model of the body which exists.

[Translation done.]

PRIOR ART

[Description of the Prior Art] The non-contact type three-dimension metering device (range finder) of a portable mold is commercialized, and it is used for the visual recognition of the data input to CG system or a CAD system, a somatometry, and a robot etc. As the non-contact measurement approach, although slit light projection (optical cutting method) is common, otherwise, pattern light projection, the stereo ** method, the interference fringe method, etc. are learned.
[0003] On the other hand, a kind of automatic vending machine which creates a user's photograph-of-his-face seal on that spot is collecting popularity. A user throws in the coin for a tariff, and he makes a favorite pose by Saki of a camera, looking at a monitor image. And if predetermined actuation is performed, the sheet with which a fixed number of seals were located in a line will be created, and it will be discharged by output port.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] According to invention of claim 1 or claim 2, three-dimension measurement can realize modeling of the configuration of a body with a difficult part like the hair configuration of the body.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] According to the above-mentioned three-dimension metering device, the configuration of the various bodies which contain the body by handiness comparable as taking a photograph can be data-ized. Since it is a non-contact type, even if it is the case where the body is measured, a measurement candidate does not sense troublesomeness.
[0005] However, in especially the optical three-dimension measurement that projects reference beams, such as slit light, the configuration of the hair part of the body may be correctly immeasurable. That is, with black hair, since the reflection factor of a reference beam is low, the light income of a range finder becomes inadequate and a measurement value tends to be missing. Moreover, the effect of a hair style is also large. For this reason, on the occasion of creation of the geometric model of a body head, there was a problem of a hair part not having been reproduced or becoming imperfect.
[0006] This invention aims at three-dimension measurement realizing modeling of the configuration of a body with a difficult part.

[Translation done.]

MEANS

[Means for Solving the Problem] In this invention, the part of an objective specific color is modeled in simple using two or more two-dimensional photography information that whenever [to a body / angle-of-coverage] differ. For example, from each of two or more two-dimensional images which photoed the body from a mutually different location and were obtained, the field which fills the setups of color information is extracted and the geometric model of the part which fills the setups in a body is generated by calculating the coordinate in the virtual space of the location on the body corresponding to each profile of two or more extracted fields. Two or more two-dimensional images which photoed the body in more detail from the location where they differ mutually as a look crosses at one point in, and were obtained Image size is arranged so that an objective representative fraction may be in agreement, it arranges to a virtual space so that each core may be in agreement and a mutual arrangement angular relation-ship may correspond to the relation of the sense of a look and a field angle, and the relative-position relation of the profile of the field which fills the setups of the color information extracted from the 2-dimensional each image is calculated. The core of an image is a pixel location corresponding to the look at the time of photography (light-receiving shaft).
[0008] A geometric model with high fidelity is obtained by using together modeling based on the three-dimension measurement information in which modeling based on two-dimensional

photography information and modeling highly precise than it are possible.
[0009] The modeling system of invention of claim 1 has a three-dimension measurement means to measure an objective three-dimension configuration and to output the 1st configuration data, a means to photo said body from a different location and to obtain two or more two-dimensional images, a means to generate the 2nd configuration data based on said two or more two-dimensional images, and a means to compound said 1st and 2nd configuration data. The hardware containing the processor for a general purpose or image processings and suitable software can constitute a means to generate configuration data, and a means to compound.
[0010] In the modeling system of invention of claim 2, said three-dimension measurement means projects a reference beam on a body, receives the reflected light, and measures a configuration based on the light-receiving output.
[0011]
[Embodiment of the Invention] Drawing 1 is the external view of the three-dimensional-model listing device 1 concerning this invention. The three-dimensional-model listing device 1 measures a body configuration, has the function to process a material on that spot based on the measurement data, and is used as an automatic vending machine of the accessories article which modeled a user's face. The goods created are the stereos with which the model of the face (the hair is included) projected from the plate surface of a predetermined configuration (for example, square). It is also possible to add a specific boom-hoisting pattern to a plate surface (a part for a background). If the suitable metallic ornaments for such goods are attached, it will become accessories, such as a pendant, a broach, and a key holder. Metallic ornaments may be beforehand attached in a material.
[0012] The floodlighting aperture 12 and the light-receiving apertures 14, 15A, and 15B are formed in the front face of the almost life-size Johan section of a case 10 with the display 16 for a user to check a pause. Optical three-dimension measurement is performed using the floodlighting aperture 12 and the light-receiving aperture 14. The light-receiving aperture 14 is used also for the two-dimensional color photography of the direction of a transverse plane. The light-receiving apertures 15A and 15B are used for the two-dimensional color photography of the direction of slant peculiar to this invention. The bottom half section of a case 10 is jutted out over the front side rather than the Johan section, and the top face serves as a control panel 18. The output port 20 of goods is established in the front face of the bottom half section.
[0013] Drawing 2 is the mimetic diagram of the busy condition of the three-dimensional-model listing device 1. The blue background sheet 2 is arranged ahead of the three-dimensional-model listing device 1. A user 3 stands toward the three-dimensional-model listing device 1, using the background sheet 2 as the back, and throws in the coin for a tariff. If a user 3 performs start actuation after that, the three-dimensional-model listing device 1 will display the three-dimension geometric model (for example, surface model) which shows a measurement result while measuring the configuration of the body which exists within the limits of [fixed] a transverse plane. And if a user 3 performs confirmation operation, the three-dimensional-model listing device 1 will start three-dimension processing according to a measurement result. Goods are completed by the time amount for about several minutes. A user 3 takes out goods from output port 20.
[0014] Drawing 3 is the top view of a control panel 18. The input port 185 of a start button 181, a confirmation button 182, Cancel button 183, a joy stick 184, and a coin is established in the control panel 18. A start button 181 is a start actuation means, and a confirmation button 182 is a

confirmation operation means. A joy stick 184 is used for modification directions of the composition of a model. In response to the Pan actuation leaned to right and left, the tilt actuation leaned up and down, and roll actuation of rotating a knob, rotation processing of a three-dimension geometric model is performed, and a processing result is displayed on serial. Moreover, Cancel button 183 is an actuation means for directing re-measurement, when the three-dimension geometric model as which the user 3 was displayed is not pleasing. However, the count of effective is set to Cancel button 183, and re-measurement cannot be directed without any restriction.

[0015] Drawing 4 is the functional block diagram of the three-dimensional-model listing device 1. The three-dimensional-model listing device 1 consists of modeling system 1A which generates the three-dimension geometric model of model size, and processing system 1B which actualizes a three-dimension geometric model.

[0016] Modeling system 1A contains the photography system 30 which changes into digital data appearance information of the user 3 who is an original body (data-izing). The photography system 30 consists of the three-dimension metering device 34 which data-izes configuration information by slit light projection, a total of three two-dimensional photography equipments (the main camera 36, auxiliary cameras 37L and 37R) which data-ize color information, and a controller 38. In addition, it may replace with slit light projection and other optical technique may be used for three-dimension measurement. The color picture data DC2 and DC3 which are the photography information on the color picture data DC 1 which are the photography information on the configuration data DS which are the measurement information by the three-dimension metering device 34, and the main camera 36, and each auxiliary cameras 37L and 37R are inputted into a data processor 40. Since the relative relation of the camera coordinate of three-dimension measurement and two-dimensional photography is known, it is easy to carry out alignment of the three-dimension geometric model based on the configuration data DS and the two-dimensional photography image. The data processor 40 is equipped with the image-processing circuit which is not illustrated, and performs various kinds of data processing including data correction peculiar to this invention. That is, a data processor 40 is a means to generate the 2nd configuration data of this invention, and is also a means to compound the 1st and 2nd configuration data. The controller 42 of a data processor 40 also bears overall control of the three-dimensional-model listing device 1, and gives the suitable directions for the controller 38 of the photography system 30, and the controller 76 of processing system 1B. A display 16 and the actuation input system 80 are connected to this controller 42. The actuation input system 80 consists of an above-mentioned control panel 18 and an above-mentioned tariff receipt device.

[0017] On the other hand, processing system 1B is equipped with the processing equipment 72 which cuts ingredients, such as a resin block, the ingredient feeder 74 which performs supply in the processing location of an ingredient, and conveyance to the output port 20 of a workpiece, the controller 76, and the output port sensor 78. The detecting signal of the output port sensor 78 is inputted into a controller 42. In addition, a controller 42 may be made to take charge of control of the photography system 30 and processing system 1B, and the circuitry which omitted the controller 38 and the controller 76 may be adopted.

[0018] Drawing 5 is the perspective view showing an example of the device configuration of processing system 1B. The ingredient feeder 74 has the stock section 210 which contains the ingredient of a total of eight sorts of configurations. Storage space is established in the both sides

of the straight-line-like migration way 212, and the elevator 220 is arranged four pieces at a time along the migration way 212 in the storage space of each **. Two or more ingredients of the same class are accumulated on each elevator 220, and vertical migration control of an elevator 220 is performed so that the best ingredient may be located in predetermined height. If one kind of ingredient suitable for the model which it is going to create is specified, the specified ingredient will extrude as a work piece 216, and will be sent out from storage space with a rod 218 on the migration way 212. And the work piece 216 on the migration way 212 is sent into the table 200 of processing equipment 72 with the migration rod 214 with a chuck.

[0019] In a table 200, a work piece 216 is fixed with two stoppers 202 and clamp fixtures 204. And it is cut with the cutters 208, such as an end mill attached in the upper and lower sides, right and left, and order at the movable revolving shaft 206.

[0020] After three-dimension processing is completed, a work piece 216 is pinched by the chuck at the tip of the migration rod 214, is carried to the edge by the side of discharge of the migration way 212, and is sent into an exhaust port 222. It may not be based on the migration rod 214, but a work piece 216 may be moved to an exhaust port 222 from a table 200 in a sliding way format.

[0021] The device configuration of processing system 1B is not restricted to instantiation. For example, if an elevator is horizontally arranged [ingredient / of the same class] at the end of the array direction on each multistage shelf and an ingredient is extruded in an elevator from a shelf, the number of elevators can be reduced. You may also carry a work piece to a stowed position -> processing location -> discharge location with an arm robot. It is also possible to replace with cutting and to create a model by technique, such as the laminating molding method (for the Mitsuzo form method to be included), laser processing (thermoforming), and molding processings (pressurization etc.). Moreover, about an ingredient configuration, a user 3 may enable it to choose a favorite appearance, and may be made to make automatic selection of that to which floor to floor time becomes the shortest from two or more sorts of ingredients which made the model of a standard face beforehand.

[0022] In the three-dimensional-model listing device 1 of the above configuration, in order to create the natural face model by which the profile of the hair section was reproduced correctly, the data correction which transforms automatically the three-dimension geometric model obtained by three-dimension measurement is made by the data processor 40. That is, the configuration of a data lack part where the effective measurement value of the hair sections is not obtained is restored based on two or more two-dimensional images.

[0023] Drawing 6 is the mimetic diagram of camera arrangement of two-dimensional photography. XYZ system of coordinates are set as the space which stands as for a user 3. To a longitudinal direction, a Y-axis is taken to a cross direction and the Z-axis is taken for the X-axis in the vertical direction. A camera station is defined according to a standard actuation posture, and the Z-axis is in agreement with the medial axis of a user's 3 head in drawing 6 .

[0024] The main camera 36 and the auxiliary cameras 37A and 37B are arranged at a radial at the circumference of the Z-axis, and each look (light-receiving shaft) crosses at one on the Z-axis (for example, origin of coordinates). The look of the main camera 36 is in agreement with a Y-axis. theta 2 is [whenever / angle-of-inclination / of the look of auxiliary camera 37L to the main camera 36 / whenever / angle-of-inclination / of the look of theta 1 and auxiliary camera 37R] the same. However, it is not necessary to necessarily make theta1 and theta2 the same whenever [angle-of-inclination].

[0025] In such camera arrangement, a user 3 is photoed from the front, auxiliary camera 37L

photos a user 3 from the method of the diagonal left, and, as for the main camera 36, auxiliary camera 37R photos a user 3 from the method of the diagonal right. In addition, it is good also as a value which may lean each look to a horizontal plane and is different for every camera in whenever [angle-of-inclination].

[0026] Drawing 7 and drawing 8 are drawings for explaining the point of the modeling based on a two-dimensional image. A data processor 40 extracts first the hair part (hair image) h to which the slash was given by drawing 7 from the two-dimensional images G1 and G2 and G3 which the color picture data DC1, DC2, and DC3 express, and extracts the profile of the hair image h further. The point of an extract of the hair image h is as follows. ** Divide a two-dimensional image into the field of a same color phase by clustering in a specific color space (for example, L* a* b* color space). ** the result -- receiving -- labeling -- carrying out -- a same color phase -- and extract the continuous field. ** Are in contact with the field of the color (blue) of the background sheet 2, and let the field of a setting hue (for example, black and the color near it) be the hair image h.

[0027] Then, the relative relation of the three dimension of the location on the body (user 3) corresponding to each profile of the 2-dimensional each images G1 and G2 and the hair image h extracted from G3 is specified. That is, the coordinate of the profile of the hair image h when setting the hair image h extracted from the two-dimensional images G1 and G2, G3, or them by photography conditions, and having arranged to three-dimension space virtually is calculated. While making in agreement the core of the image shown with a notation (+) by drawing 7 on the occasion of the arrangement to three-dimension space and making a mutual arrangement angular relation-ship correspond to the relation between the look at the time of photography, and the sense of a field angle, it expands or reduces if needed so that an objective representative fraction may be in agreement. The core of an image is a pixel location corresponding to the look at the time of photography. With this operation gestalt, since the look at the time of photography is in the same flat surface, the 2-dimensional each images G1 and G2 and G3 are made to meet the Z-axis, and if only include angles theta1 and theta2 lean and arrange the two-dimensional image G2 and G3 to the two-dimensional image G1, the sense of a field angle will gather. If the photography scale factor is set up identically, there will be no need for expansion/contraction. In addition, since the relative-position relation of the hair image h should just be known, it is not necessary to make the hair image h into the magnitude which ****s on a body in this phase. Drawing 7 (B) is the top view showing the physical relationship of the profile of the hair image h on one flat surface perpendicular to the Z-axis. When the rim of the hair is modeled, especially the location of two points of both ends is important among the locations of X shaft orientations of the profile in the attention location of Z shaft orientations.

[0028] Next, the contour line Lh of an epilogue and the hair is computed for the intersection when cutting in respect of being perpendicular to the profile and the Z-axis of a total of three hair images h by which virtual arrangement was carried out (level surface) by the B spline curve. And let the field (surface) which connected the contour line Lh in two or more locations of Z shaft orientations by smoothing be the geometric model Uh of a hair part.

[0029] Drawing 9 is the mimetic diagram of composition of a geometric model. Alignment is made three-dimension space, the geometric model Uh of the hair part created in the above-mentioned way and a user's 3 geometric model Uf obtained by three-dimension measurement are arranged to it, the set operation which asks for both sum is performed, and it compounds to one geometric model UM. At this time, when it treats as an auxiliary model which restores lack of

measurement and conflict of a lap arises, the geometric model Uh of a hair part gives priority to a geometric model Uf in principle, and adds data correction.
[0030] Thus, even if some data of the hair were not obtained in three-dimension measurement by processing it using the obtained geometric model UM, the face model which reproduced the outline of the hair correctly can be created.
[0031] Hereafter, a flow chart explains actuation of the three-dimensional-model listing device 1. Drawing 10 is the Maine flow chart which shows actuation of an outline. After a power source is switched on, in the waiting period which waits for actuation by the user, two-dimensional photography and the display of a photography result are repeated (#10, #12, #14). Moreover, a guidance message is displayed periodically. If a tariff is injected and a start button 181 is pushed, while performing two-dimensional photography anew, three-dimension measurement will be performed (#16, #18). Predetermined data processing is performed (#20) and the obtained three-dimension geometric model is displayed (#22). At this time, appearance is raised with the application of the well-known graphic technique of attaching a shadow. And it waits for directions actuation. However, the latency time is limited, and if it passes over the time limit, it will be considered that it is that to which confirmation operation was performed.
[0032] If a joy stick 184 is operated, a three-dimension geometric model will be rotated according to actuation as mentioned above, and it will display (#24, #38). If Cancel button 183 is pushed, it will return to actuation of a waiting period (#40, #10). However, re-measurement will be performed, if a user does not need to inject a tariff anew and pushes a start button 181 in this case.
[0033] A push on a confirmation button 182 generates the data for processing control with reference to a processing condition database based on a three-dimension geometric model (#28). (#26) An ingredient is processed (#30). After processing finishes, goods are discharged (#32), and it checks that goods have been taken out by the output port sensor 78, and returns to standby actuation (#34, #10).
[0034] Drawing 11 is a flow chart which shows the contents of data processing of drawing 10 . By this routine, the next processing including the data correction which restores the configuration of the hair as mentioned above and compaction of floor to floor time, or compression of the depth direction for intentional flattening on a design is performed.
[0035] While performing data smoothing and removing the abnormality data based on a noise, it avoids that excess reappears to fine irregularity (#200). Re-sampling processing is performed (#210). This is processing changed into the data which aligned by the lattice point of spacing, such as having carried out parallel projection from a certain direction, in order to make the right pair of the input data carry out in the processing direction, when the face has turned to slant. For example, when the bottom of the lug of people's face becomes shade and cannot measure, after wearing a face upward and carrying out three-dimension measurement, data are convertible so that the face which turned to the usual transverse plane may be expressed. When there is no measure point in the location where the lattice point was projected, the measurement value of the perimeter performs a linearity complement. At this time, it becomes the vertical upper part at the time of the projected direction processing it, and each lattice point has data of height. Moreover, even when input data is based on a perspective projection, input data can be changed into parallel projection data by this processing.
[0036] A fine deficit part without data is complemented (#220). As the complement technique, various technique, such as a linearity complement and weighting ****, is applicable. For

example, all the parts into which data are missing are replaced with a fixed value (simple complement). As the fixed value, the average of the set point, the minimum height, and the periphery location of a face can be considered. When the deficit section is completely surrounded in the effective-data part, a linearity complement is carried out from surrounding data. Thereby, the deficit part in the face (for example, black eyebrows) is restored.

[0037] The geometric model Uh of a hair part is created in the way mentioned above, and it compounds with the geometric model Uf based on the observation data of a three dimension. That is, the partial correction which adds the hair is made to a geometric model Uf (#230). Stripes-like boom hoisting is added to a hair part in this phase, texture can be raised or emphasis which heaps up particular parts, such as an eye, an iris-of-the-eye part, eyebrows, a lip, and a cheek, a little can be performed.

[0038] After obtaining the geometric model UM faithful to an object configuration by each above processing, height compression processing is performed and the dimension of a three-dimension geometric model is contracted in the depth direction (#240). If the difference of elevation of the depth direction becomes small, floor to floor time will become short. Moreover, for the application of a pendant or a medal, a superficial model is suitable. To compression, both of the technique, uniform compression and un-uniform compression, can be applied, and it can also use properly for every part to it.

[0039] A part for the background of the three-dimension geometric models is detected (#250). This is pretreatment for correcting a part for a background. If a user's tooth back is considered as the blue back with the background sheet 3, a part for a background is certainly [easily and] detectable with color distinction of a two-dimensional image.

[0040] Background conversion transposed to other data about a part for a background is performed (#260). For example, since depth is extremely deep, a part for a background is changed into data with shallow depth in order to shorten floor to floor time. The solid side data which express patterns and geometric patterns, such as flowering trees and shrubs, also by flat-surface data are sufficient as the data to replace.

[0041] Size adjustment in which a full-scale three-dimension geometric model is fitted to goods size is performed (#270). Moreover, resolution conversion in which the amount of data is fitted to the precision of processing equipment 72 is performed (#280). Although this processing projects the mesh of predetermined grid width of face and it re-samples in the lattice point, the direction to project is being fixed in the direction of a vertical at the time of processing. As the point of resolution conversion (the number conversion of data), first, the pitch between points and ** KUTORU variation define the configuration point group of the geometric model for processing, and the pitch range between points corresponding to ** KUTORU variation is read from the property data table memorized beforehand, and is set up. That is, data are thinned out, a pitch is enlarged, or data are interpolated and a pitch is made small. What is necessary is only just to cull out, when the resolution of measurement is large enough. If the resolution conversion function is prepared, since the resolution of the three-dimension metering device 34 will not be limited, the use gestalt of exchanging a measurement means according to an application will be permitted.

[0042] Alignment to which the parallel displacement of the zero of a coordinate is carried out so that the criteria location of a three-dimension geometric model may suit the last in the criteria location of processing is performed (#290). In addition, when using the ingredient with which predetermined irregularity was made above beforehand on the occasion of processing, in the

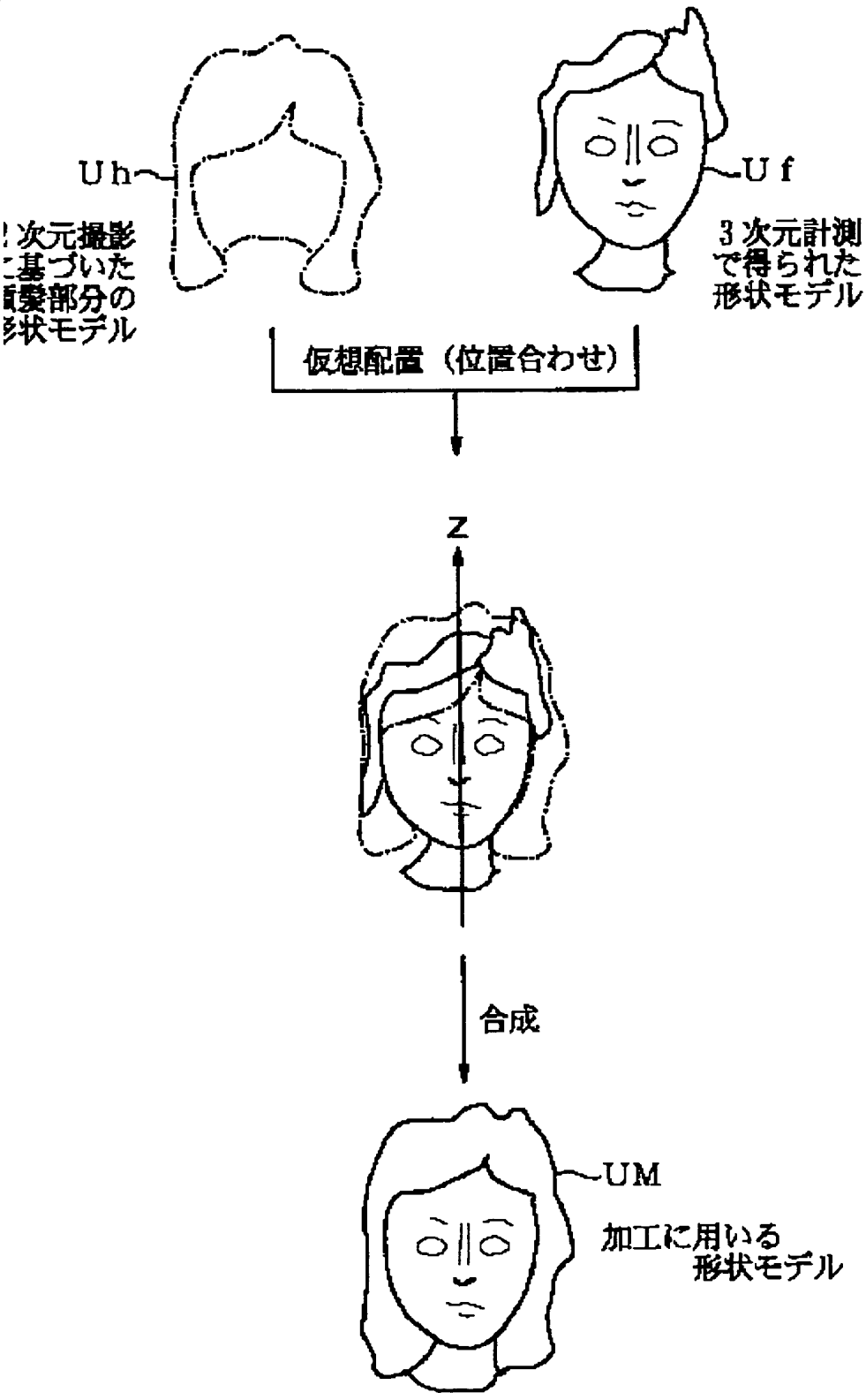
processing data generation processing (#28 of drawing 10) in response to confirmation operation, the amount of cutting is computed by comparing the three-dimension geometric model obtained by the above processing with the irregularity made.
[0043] Drawing 12 is the flow chart of the partial correction subroutine of drawing 11 . As drawing 7 explained, the two-dimensional images G1 and G2 and G3 which are the photography information on three directions first are incorporated (#301), and it is L* a* b*. Field division in a color space is performed (#302). The field of a setting hue is distinguished from the hair image h (#303), and the profile is extracted (#304). It asks for the high line Lh, such as having corresponded to the profile of the hair image h, (#305), a contour line Lh is connected, and the geometric model Uh of the hair is generated (#306). And the geometric model Uh of the hair based on a two-dimensional image and the geometric model Uf based on three-dimension measurement are compounded (#307).
[0044] the above operation gestalt -- setting -- the scalp from three-dimension measurement data -- the scalp the configuration of a field was presumed to be and the configuration created from the two-dimensional image was presumed to be in the following ways with reference to the result -- it is desirable to make it not become inside a field.
[0045] drawing 13 -- the scalp -- the mimetic diagram of presumption of a field configuration, and drawing 14 -- the scalp -- it is the flow chart which shows an example of the creation point of a field geometric model. The profile of a user's 3 head is obtained from the geometric model Uf which consists of a face field Uf1 and a hair field Uf2 (#3051). the middle point (black dot of drawing 13) between the points with which two or more suitable points on a profile (white round head of drawing 13) were chosen and which were adjoined of the selected point or them -- a control point -- carrying out -- a spline curve -- the scalp -- a field configuration is approximated (#3052, #3053). The approximation curve which passes along the inside of the profile of the hair is obtained by making the point on a profile into a control point about the face field Uf1, and making the middle point into a control point about the hair field Uf2. two or more approximation curves in the same way -- asking -- between them -- surface -- interpolating -- the scalp -- the field geometric model Us is obtained (#3054).
[0046] Although the three-dimensional-model listing device 1 supposing the use as an automatic vending machine was illustrated with the above-mentioned operation gestalt, it does not ask whether data processing concerning this invention is whether model creation is onerous and onerous. Not only contraction size but actual size or expansion size is sufficient as the size of a model. the geometric model UM obtained by composition with the geometric model Uh based on two or more two-dimensional images and the geometric model Uf based on three-dimension measurement data can be used for an application at versatility other than model creation, such as a display and animation creation.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the external view of the three-dimensional-model listing device concerning this invention.
[Drawing 2] It is the mimetic diagram of the busy condition of a three-dimensional-model listing device.
[Drawing 3] It is the top view of a control panel.
[Drawing 4] It is the functional block diagram of a three-dimensional-model listing device.
[Drawing 5] It is the perspective view showing an example of the device configuration of a processing system.
[Drawing 6] It is the mimetic diagram of camera arrangement of two-dimensional photography.
[Drawing 7] It is drawing for explaining the point of the modeling based on a two-dimensional image.
[Drawing 8] It is drawing for explaining the point of the modeling based on a two-dimensional image.
[Drawing 9] It is the mimetic diagram of composition of a geometric model.
[Drawing 10] It is the Maine flow chart which shows actuation of an outline.
[Drawing 11] It is the flow chart which shows the contents of data processing of drawing 10 .
[Drawing 12] It is the flow chart of the partial correction subroutine of drawing 11 .
[Drawing 13] the scalp -- it is the mimetic diagram of presumption of a field configuration.
[Drawing 14] the scalp -- it is the flow chart which shows an example of the creation point of a field geometric model.
[Description of Notations]
1A Modeling system
3 User (Body)
30 Photography System
34 Three-Dimension Metering Device (Three-Dimension Measuring Device)
40 Data Processor
G1-3 Two-dimensional image
Uf Geometric model (1st configuration data)
Uh Geometric model (2nd configuration data)

[Translation done.]


Uh
次元撮影
に基づいた
頭髪部分の
形状モデル
Uf
3次元計測
で得られた
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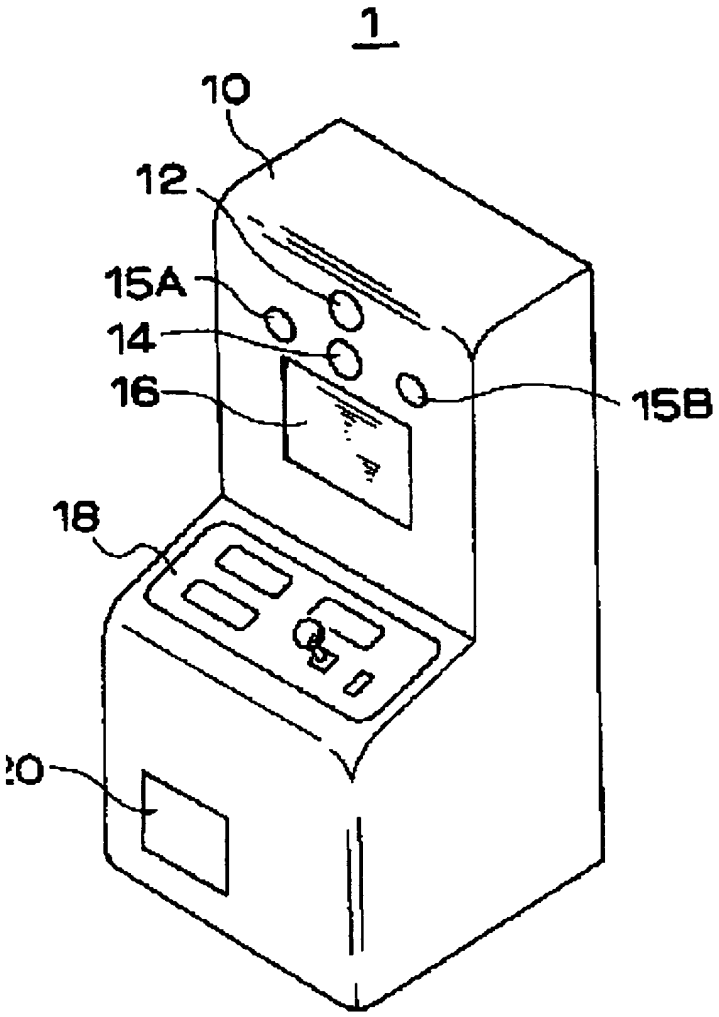
仮想配置（位置合わせ）
Z
合成
UM
加工に用いる
形状モデル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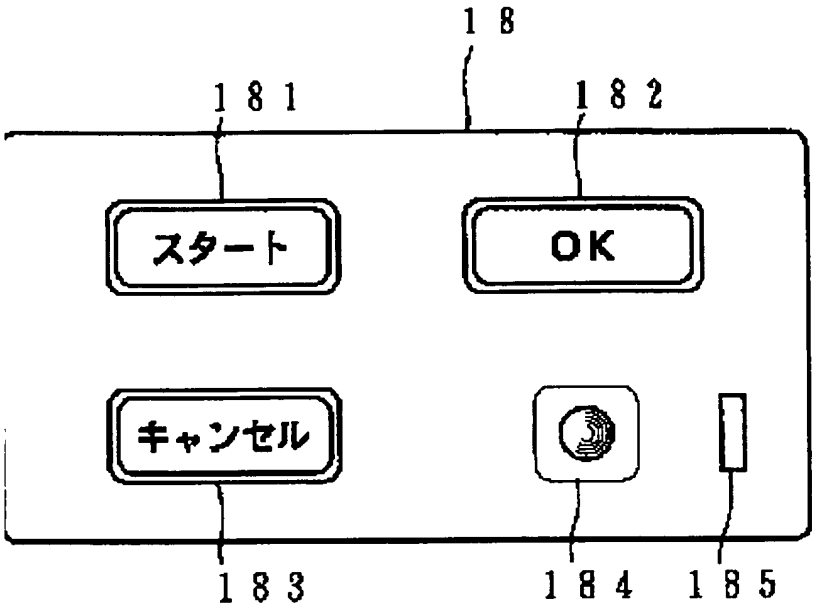
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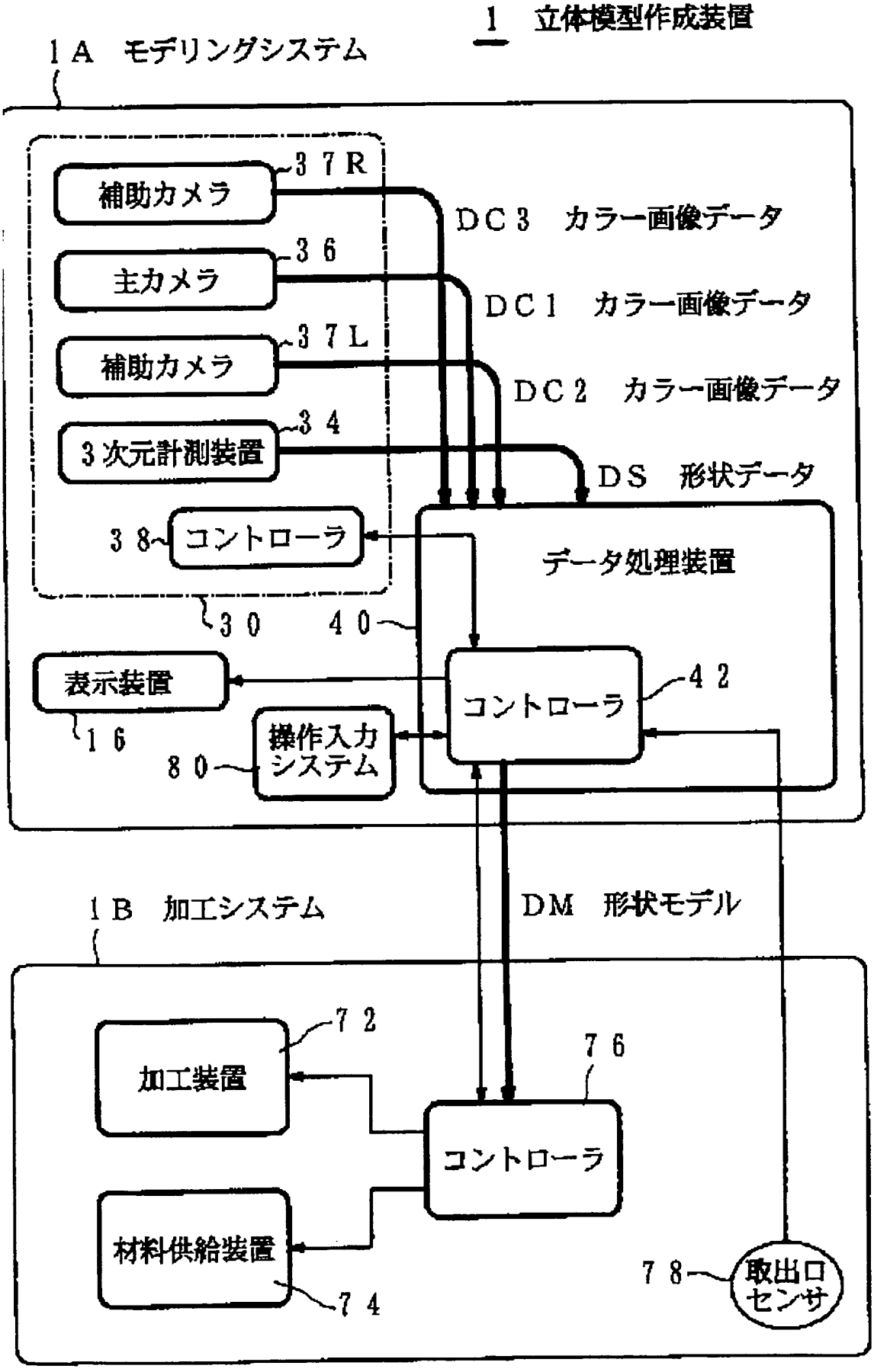
1 立体模型作成装置
1A モデリングシステム
補助カメラ
37R
DC3 カラー画像データ
主カメラ
36
DC1 カラー画像データ
補助カメラ
37L
DC2 カラー画像データ
3次元計測装置
34
DS 形状データ
38
コントローラ
データ処理装置
30
40
表示装置
16
コントローラ
42
操作入力システム
80
1B 加工システム
DM 形状モデル
加工装置
72
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コントローラ
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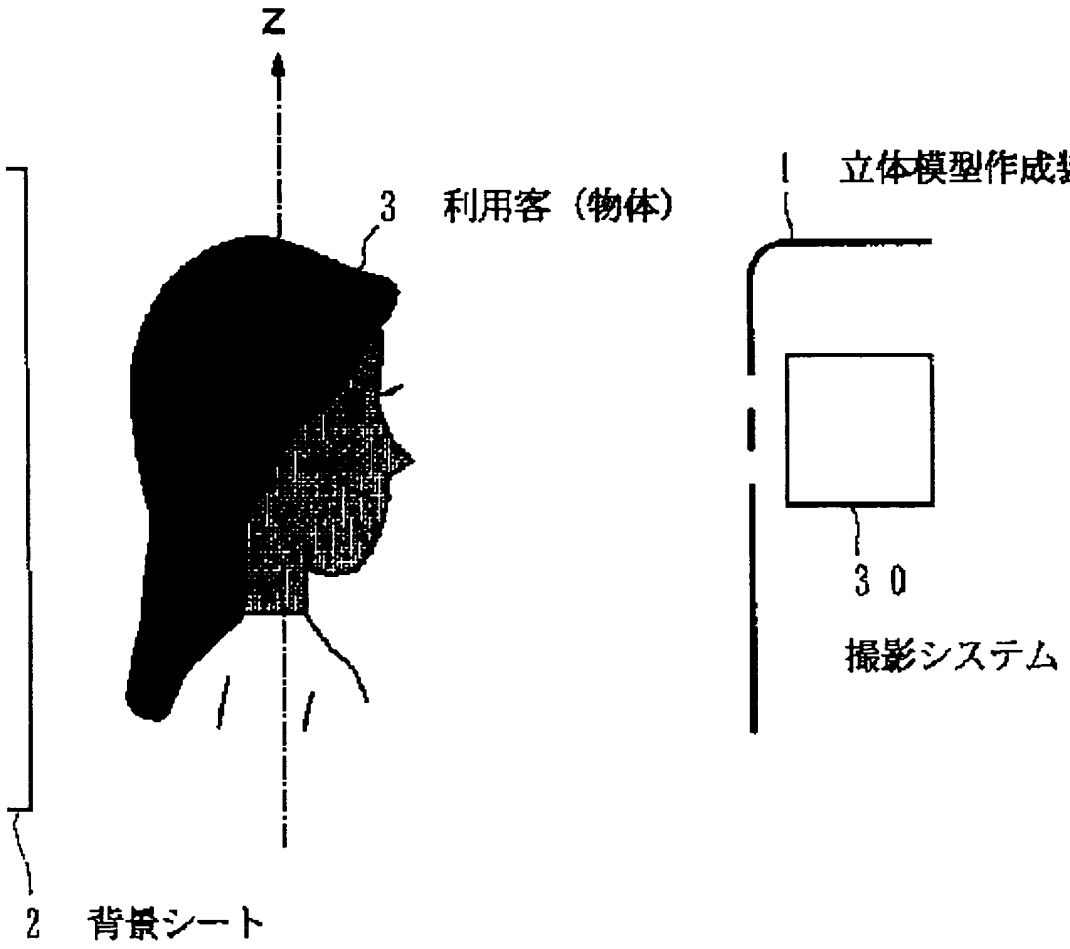
取出口センサ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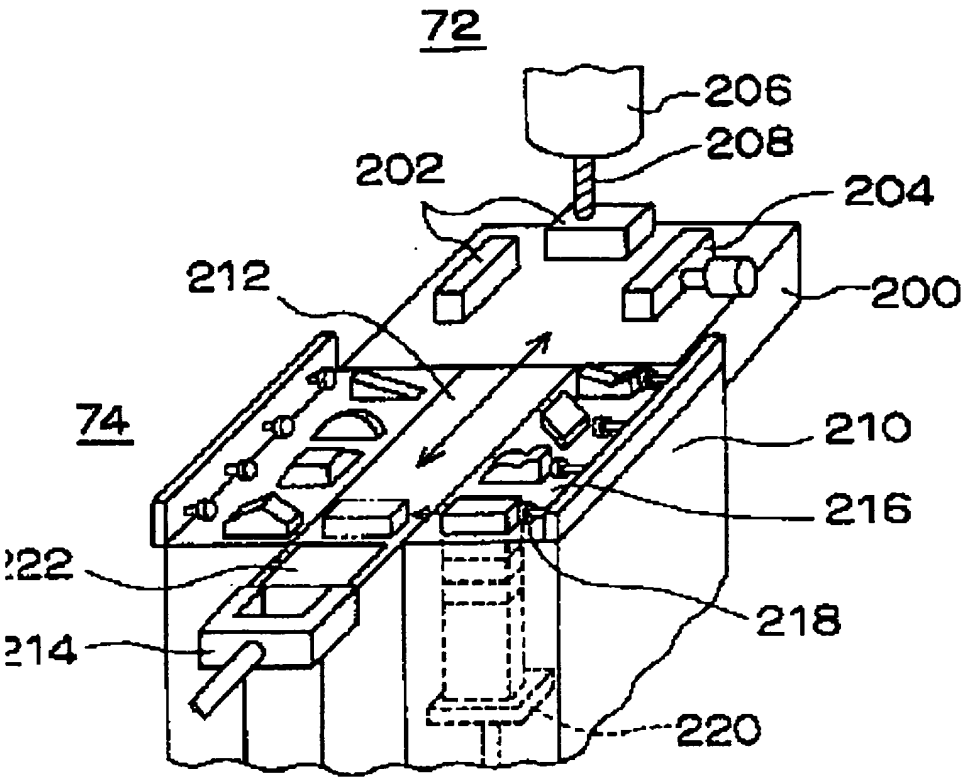
1 立体模型作成装置
3 利用客（物体）
30
撮影システム
2 背景シート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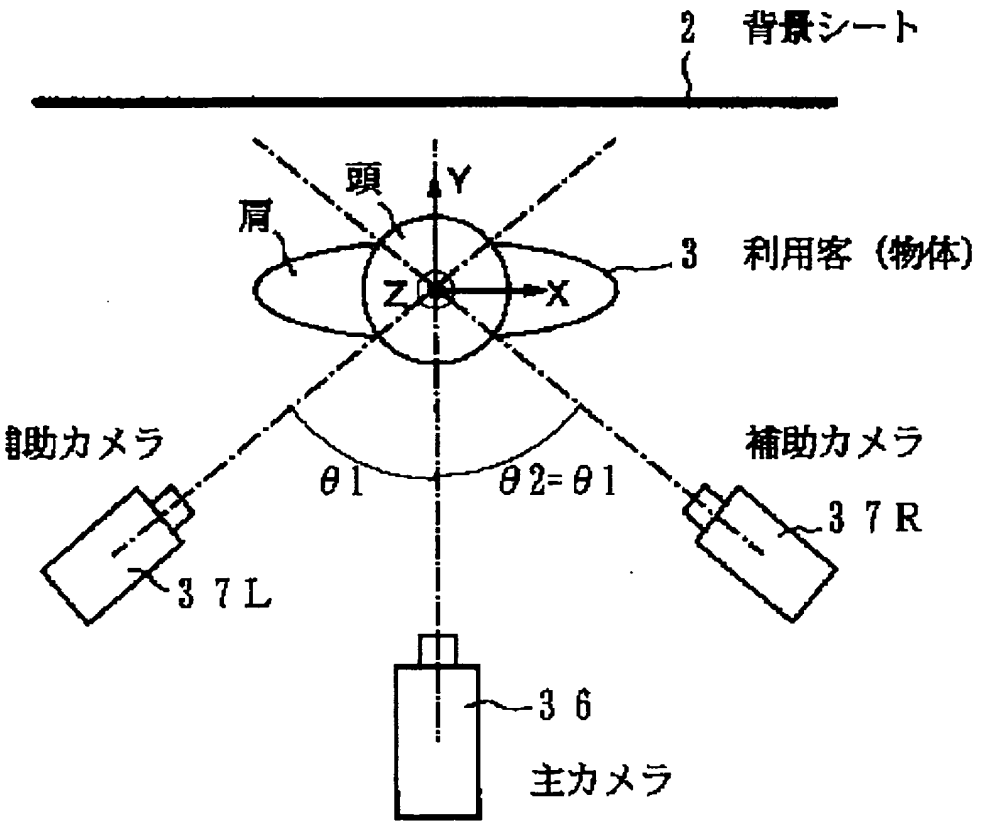
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頭
Y
肩
3 利用客（物体）
Z
X
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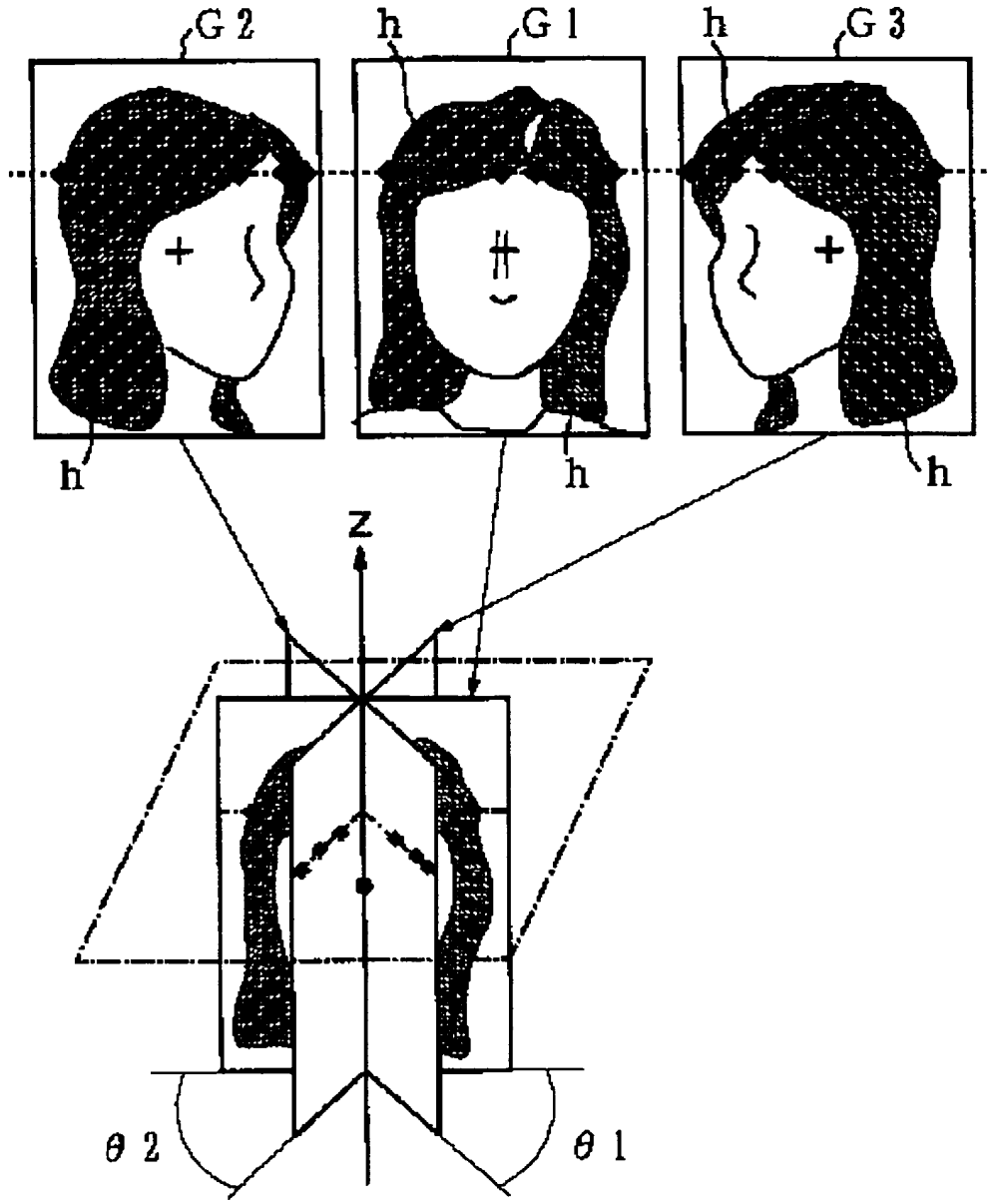
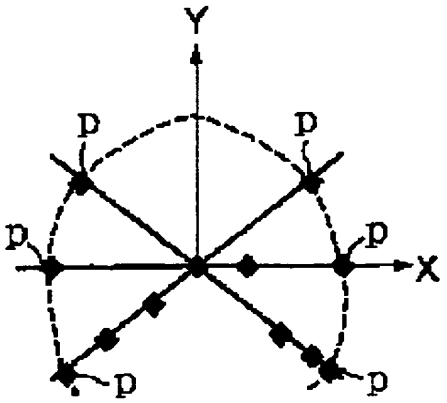
θ1
θ2=θ1
補助カメラ
37R
37L
36
主カメラ

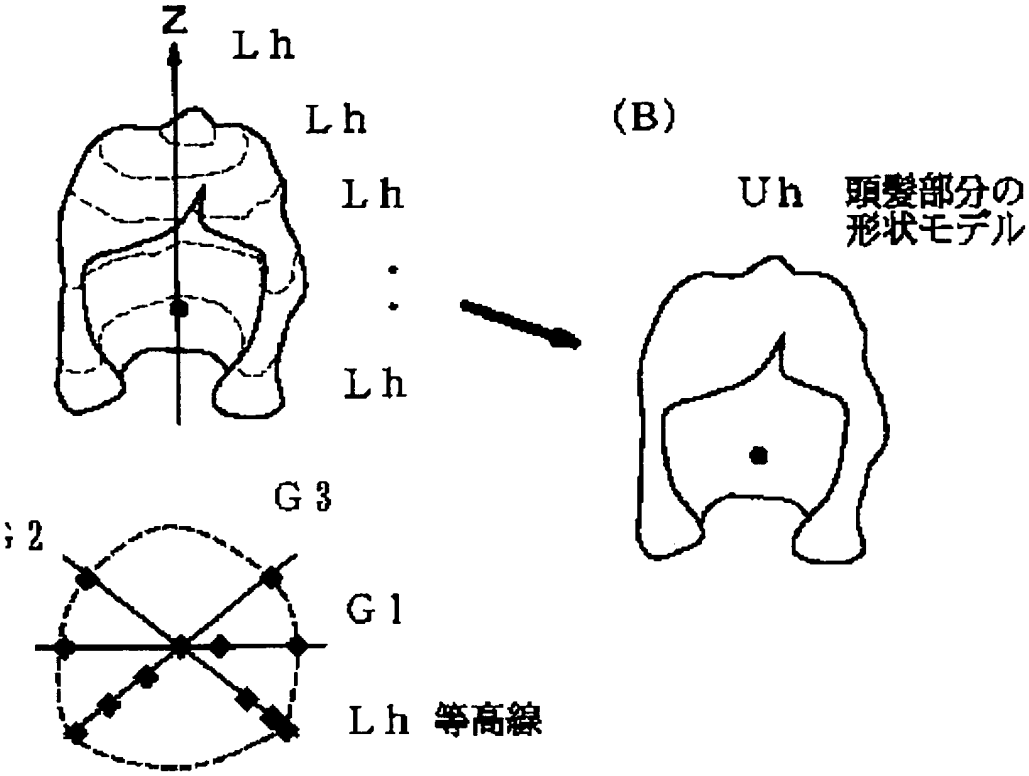
A)

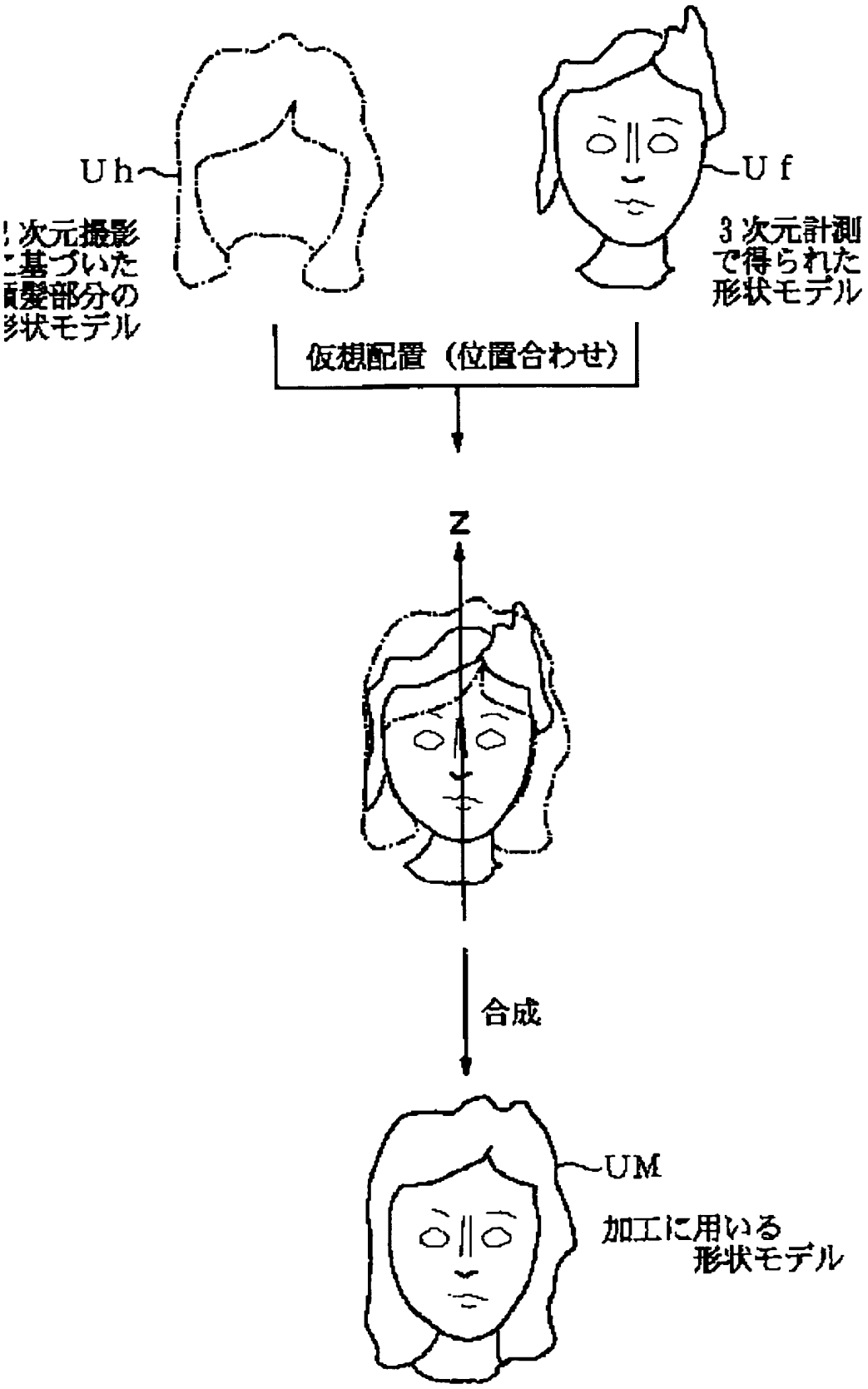


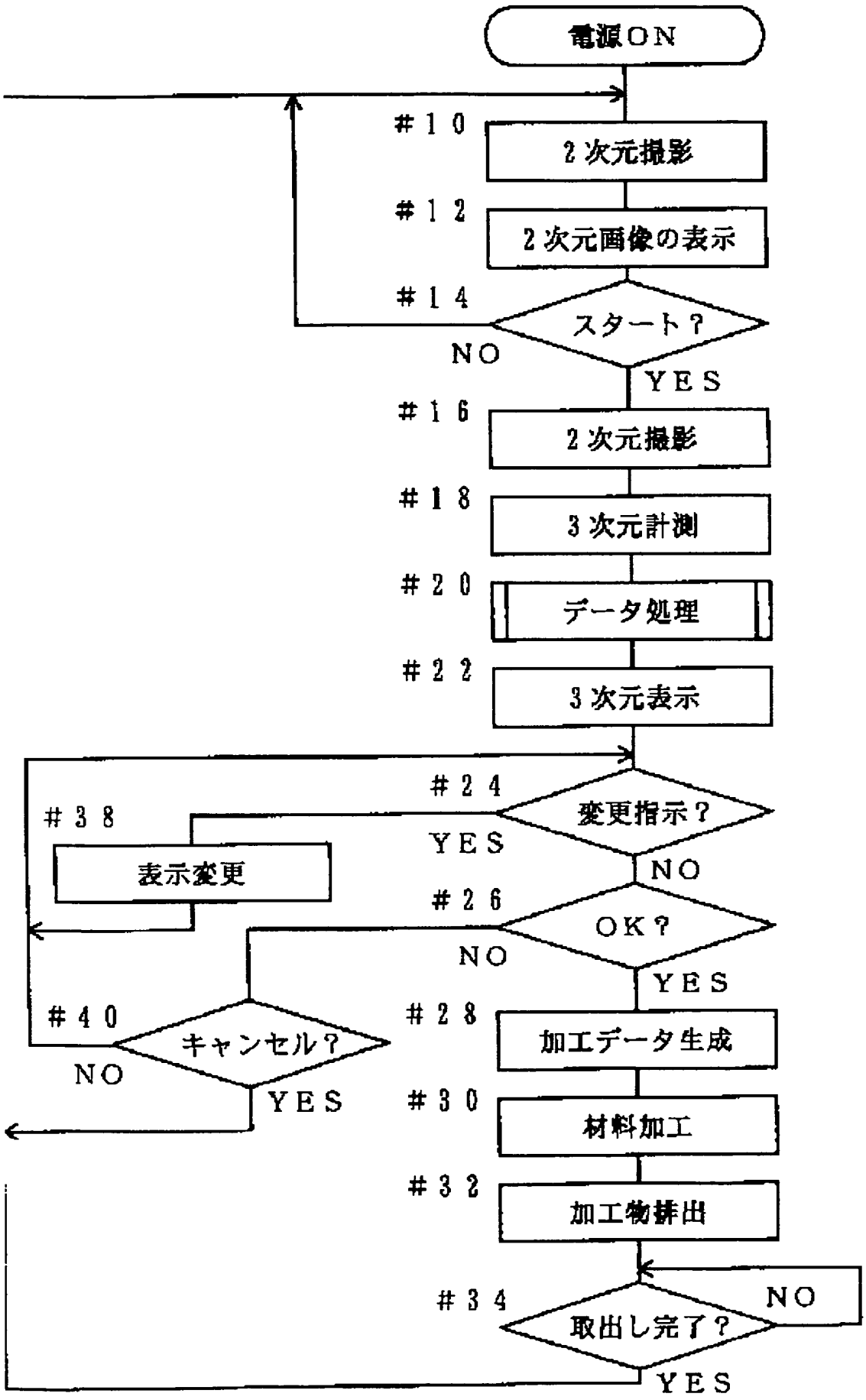
(B)

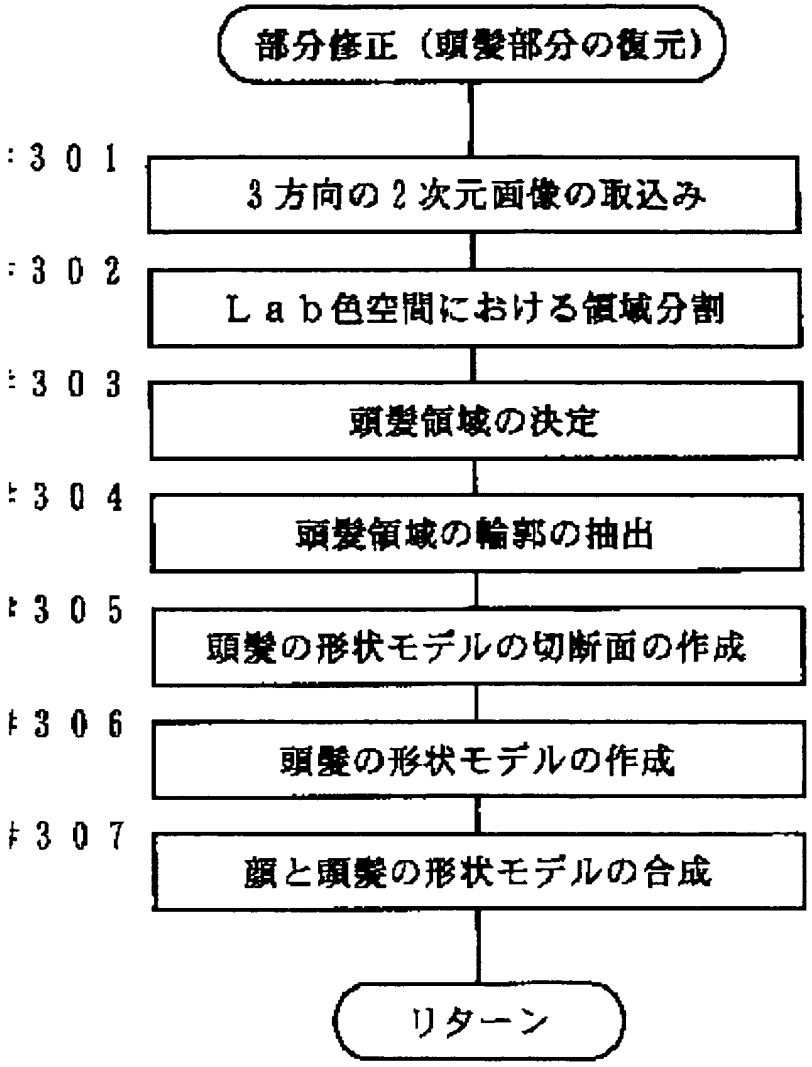


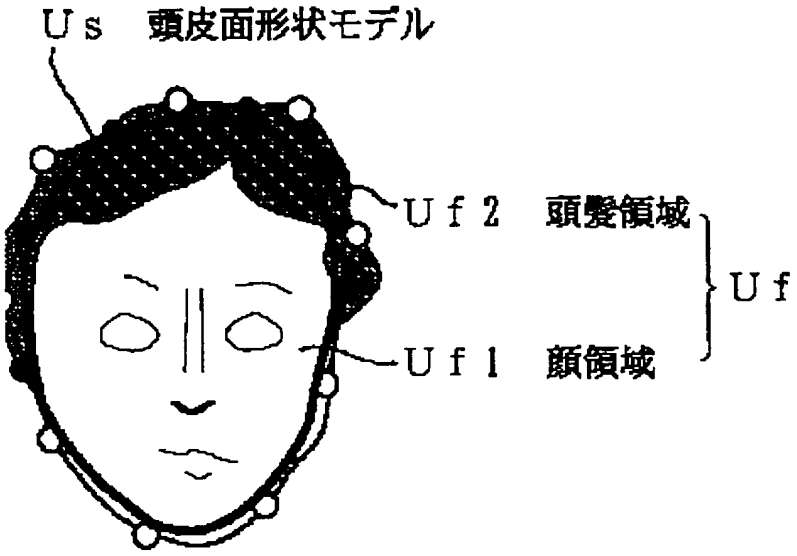
(A)

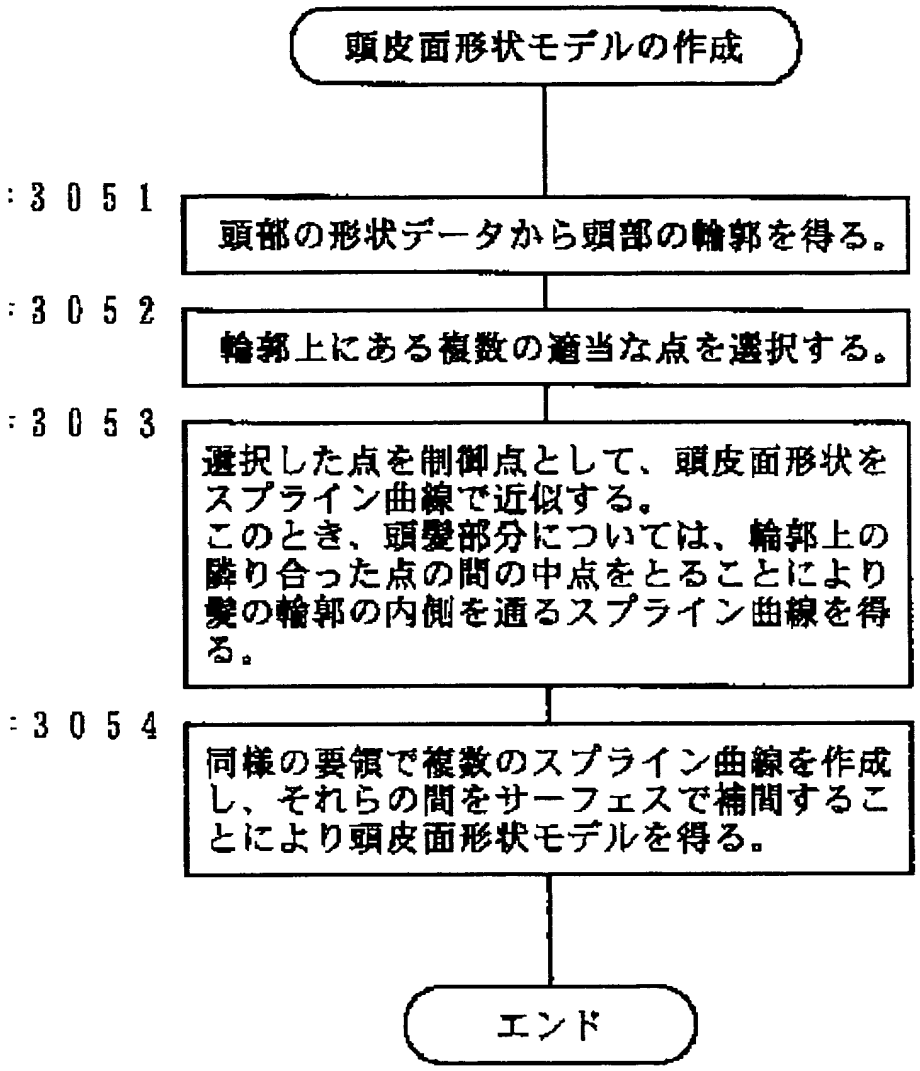



Uh
次元撮影
に基づいた
頭髪部分の
形状モデル
Uf
3次元計測
で得られた
形状モデル
仮想配置（位置合わせ）
Z
合成
UM
加工に用いる
形状モデル


電源ON
#10
2次元撮影
#12
2次元画像の表示
#14
スタート？
NO
YES
#16
2次元撮影
#18
3次元計測
#20
データ処理
#22
3次元表示
#24
変更指示？
YES
#38
表示変更
NO
#26
OK？
NO
YES
#40
キャンセル？
NO
YES
#28
加工データ生成
#30
材料加工
#32
加工物排出
#34
取出し完了？
NO
YES


部分修正（頭髪部分の復元）
301
3方向の2次元画像の取込み
302
Ｌａｂ色空間における領域分割
303
頭髪領域の決定
304
頭髪領域の輪郭の抽出
305
頭髪の形状モデルの切断面の作成
306
頭髪の形状モデルの作成
307
顔と頭髪の形状モデルの合成
リターン


Ｕｓ　頭皮面形状モデル
Ｕｆ２　頭髪領域
Ｕｆ１　顔領域
Ｕｆ


頭皮面形状モデルの作成
3051
頭部の形状データから頭部の輪郭を得る。
3052
輪郭上にある複数の適当な点を選択する。
3053
選択した点を制御点として、頭皮面形状をスプライン曲線で近似する。
このとき、頭髪部分については、輪郭上の隣り合った点の間の中点をとることにより髪の輪郭の内側を通るスプライン曲線を得る。
3054
同様の要領で複数のスプライン曲線を作成し、それらの間をサーフェスで補間することにより頭皮面形状モデルを得る。
エンド

MODELING SYSTEM

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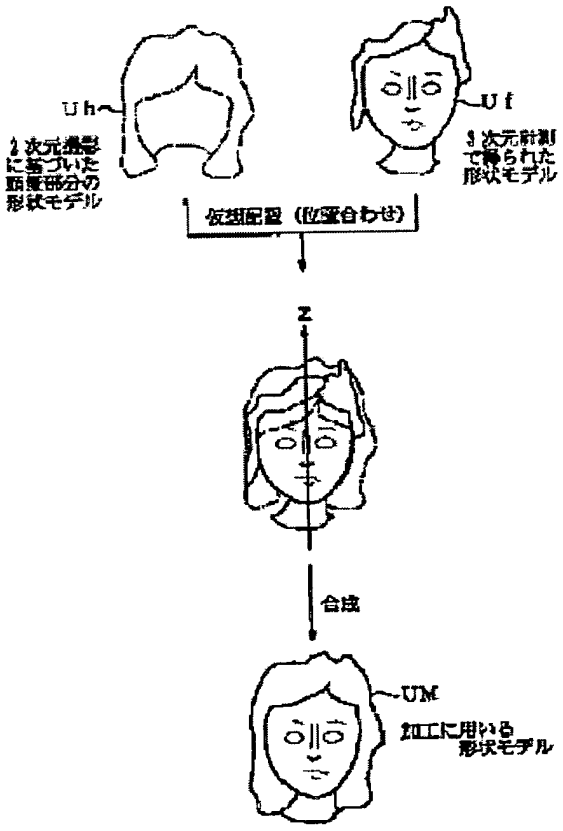
Publication date: 1999-11-30
Inventor: BAN SHINICHI
Applicant: MINOLTA CO LTD
Classification:
- international: ***G06T5/00; G06T7/00; G06T17/00;*** **G06T5/00; G06T7/00; G06T17/00;** (IPC1-7): G06T17/00; G06T5/00; G06T7/00
- european:
Application number: JP19980137912 19980520
Priority number(s): JP19980137912 19980520

Abstract of **JP11328444**

PROBLEM TO BE SOLVED: To model the shape of a body having a part which is hardly measured in three dimensions by synthesizing three-dimensional shape data with plural two-dimensional shape data of the body.
SOLUTION: A generated shape model Uh for a head hair part and a shape model Uf for a customer obtained through three-dimensional measurement are positioned and arranged in a three-dimensional space and set operation for finding the sum of the both is performed to synthesizing one shape model UM. At this time, the shape model Uh for the head hair part is handled as an auxiliary model for restoring deficiencies of the measurement and when superposition is contradictory, data corrections are made while priority is given to the shape model Uf in principle. The shape model UM which is thus obtained is used to perform processing and then even if data of part of the head hair is not obtained by the three-dimensional measurement, a face model having the outline of the head hair correctly reproduced can be generated.



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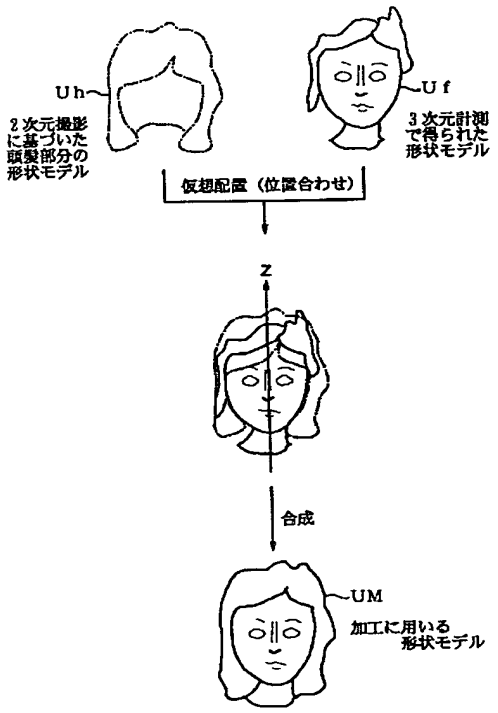
(54)【発明の名称】　モデリングシステム

(57)【要約】
【課題】３次元計測が困難な部分を有した物体の形状のモデル化を実現する。
【解決手段】物体の３次元形状を測定して第１の形状データＵｆを出力する３次元測定手段と、物体を異なる位置から撮影して複数の２次元画像を得る手段と、複数の２次元画像に基づいて第２の形状データＵｈを生成する手段と、第１及び第２の形状データを合成する手段とを有したモデリングシステムを用いる。



【特許請求の範囲】
【請求項１】物体の３次元形状を測定し、第１の形状データを出力する３次元測定手段と、
前記物体を異なる位置から撮影し、複数の２次元画像を得る手段と、
前記複数の２次元画像に基づいて第２の形状データを生成する手段と、
前記第１及び第２の形状データを合成する手段と、を有することを特徴とするモデリングシステム。
【請求項２】前記３次元測定手段は、物体に参照光を投射し、その反射光を受光し、その受光出力に基づいて形状を測定する請求項１記載のモデリングシステム。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、実存する物体の形状モデルを生成するモデリングシステムに関し、例えば人体頭部の模型の作成に利用される。
【０００２】
【従来の技術】可搬型の非接触式３次元計測装置（レンジファインダ）が商品化され、ＣＧシステムやＣＡＤシステムへのデータ入力、身体計測、ロボットの視覚認識などに利用されている。非接触の計測方法としては、スリット光投影法（光切断法）が一般的であるが、他にもパターン光投影法、ステレオ視法、干渉縞法などが知られている。
【０００３】一方、利用客の顔写真シールをその場で作成する一種の自動販売機が人気を集めている。利用客は料金分の硬貨を投入し、モニタ画像を見ながらカメラの前で好みのポーズをとる。そして、所定の操作を行うと、一定数のシールが並んだシートが作成されて取出口に排出される。
【０００４】
【発明が解決しようとする課題】上述の３次元計測装置によれば、写真をとるのと同程度の手軽さで人体を含む各種物体の形状をデータ化することができる。非接触式であるので、人体を計測する場合であっても、計測対象者が煩わしさを感じることはない。
【０００５】しかし、特にスリット光などの参照光を投射する光学式の３次元計測では、人体の頭髪部分の形状を正確に計測できない場合がある。つまり、黒髪では参照光の反射率が低いので、レンジファインダの受光量が不十分になって計測値が欠落し易い。また、ヘアースタイルの影響も大きい。このため、人体頭部の形状モデルの作成に際して、頭髪部分が再現されなかったり不完全になったりするという問題があった。
【０００６】本発明は、３次元計測が困難な部分を有した物体の形状のモデル化を実現することを目的としている。
【０００７】
【課題を解決するための手段】本発明においては、物体に対する撮影角度の異なる複数の２次元撮影情報を用いて、物体の特定色の部分を簡易的にモデル化する。例えば、物体を互いに異なる位置から撮影して得られた複数の２次元画像のそれぞれから、色情報の設定条件を満たす領域を抽出し、抽出した複数の領域のそれぞれの輪郭に対応した物体上の位置の仮想空間での座標を算定することによって、物体における設定条件を満たす部分の形状モデルを生成する。さらに詳しくは、物体を視線が１点で交わるようにして互いに異なる位置から撮影して得られた複数の２次元画像を、物体の縮尺率が一致するように画像サイズを揃えて、それぞれの中心が一致し且つ互いの配置角度関係が視線及び画角の向きの関係に対応するように仮想空間に配置し、各２次元画像から抽出した色情報の設定条件を満たす領域の輪郭の相対位置関係を算定する。画像の中心とは、撮影時の視線（受光軸）に対応した画素位置である。
【０００８】２次元撮影情報に基づくモデル化とそれよりも高精度のモデル化が可能な３次元計測情報に基づくモデル化とを併用することにより、忠実度の高い形状モデルを得る。
【０００９】請求項１の発明のモデリングシステムは、物体の３次元形状を測定して第１の形状データを出力する３次元測定手段と、前記物体を異なる位置から撮影して複数の２次元画像を得る手段と、前記複数の２次元画像に基づいて第２の形状データを生成する手段と、前記第１及び第２の形状データを合成する手段と、を有する。形状データを生成する手段及び合成する手段は、汎用又は画像処理用のプロセッサを含むハードウェア、及び適切なソフトウェアによって構成することができる。
【００１０】請求項２の発明のモデリングシステムにおいて、前記３次元測定手段は、物体に参照光を投射し、その反射光を受光し、その受光出力に基づいて形状を測定するものである。
【００１１】
【発明の実施の形態】図１は本発明に係る立体模型作成装置１の外観図である。立体模型作成装置１は、物体形状を計測し、その計測データに基づいて素材をその場で加工する機能を有しており、利用客の顔をかたどった小物品の自動販売機として使用される。作成される物品は、所定形状（例えば四角形）の板面から顔面（頭髪を含む）の模型が突き出た立体である。板面（背景部分）に特定の起伏模様を付加することも可能である。このような物品に適当な金具を取り付ければ、ペンダント、ブローチ、キーホルダなどのアクセサリーとなる。あらかじめ素材に金具を取り付けておいてもよい。
【００１２】ほぼ等身大の筐体１０の上半部の前面に、利用客がポーズを確認するためのディスプレイ１６とともに、投光窓１２及び受光窓１４，１５Ａ，１５Ｂが設けられている。投光窓１２及び受光窓１４を用いて光学式の３次元計測が行われる。受光窓１４は正面方向の２

次元カラー撮影にも用いられる。受光窓１５Ａ，１５Ｂは本発明に特有の斜め方向の２次元カラー撮影に用いられる。筐体１０の下半部は上半部よりも前方側に張り出しており、その上面が操作パネル１８となっている。商品の取出口２０は下半部の前面に設けられている。

【００１３】図２は立体模型作成装置１の使用状態の模式図である。立体模型作成装置１の前方に例えばブルーの背景シート２が配置されている。利用客３は背景シート２を背にして立体模型作成装置１に向かって立ち、料金分の硬貨を投入する。その後に利用客３がスタート操作を行うと、立体模型作成装置１は正面の一定範囲内に存在する物体の形状を計測するとともに、計測結果を示す３次元形状モデル（例えばサーフェスモデル）を表示する。そして、利用客３が確認操作を行うと、立体模型作成装置１は計測結果に応じた３次元加工を開始する。数分程度の時間で商品が完成する。利用客３は取出口２０から商品を取り出す。

【００１４】図３は操作パネル１８の平面図である。操作パネル１８には、スタートボタン１８１、確認ボタン１８２、キャンセルボタン１８３、ジョイスティック１８４、及び硬貨の投入口１８５が設けられている。スタートボタン１８１はスタート操作手段であり、確認ボタン１８２は確認操作手段である。ジョイスティック１８４は模型の構図の変更指示に用いられる。左右に傾けるパーン操作、上下に傾けるチルト操作、及びノブを回転させるロール操作に呼応して３次元形状モデルの回転処理が行われ、処理結果が逐次に表示される。また、キャンセルボタン１８３は、利用客３が表示された３次元形状モデルが気に入らないときなどに再計測を指示するための操作手段である。ただし、キャンセルボタン１８３には有効回数が設定されており、無制限に再計測を指示することはできない。

【００１５】図４は立体模型作成装置１の機能ブロック図である。立体模型作成装置１は、模型サイズの３次元形状モデルを生成するモデリングシステム１Ａと、３次元形状モデルを顕在化する加工システム１Ｂとから構成されている。

【００１６】モデリングシステム１Ａは、オリジナル物体である利用客３の外観情報をディジタルデータに変換（データ化）する撮影システム３０を含んでいる。撮影システム３０は、スリット光投影法で形状情報をデータ化する３次元計測装置３４、色情報をデータ化する計３個の２次元撮影装置（主カメラ３６、補助カメラ３７Ｌ，３７Ｒ）、及びコントローラ３８からなる。なお、３次元計測にスリット光投影法に代えて他の光学式手法を用いてもよい。３次元計測装置３４による計測情報である形状データＤＳ、主カメラ３６の撮影情報であるカラー画像データＤＣ１、及び各補助カメラ３７Ｌ，３７Ｒの撮影情報であるカラー画像データＤＣ２，ＤＣ３はデータ処理装置４０に入力される。３次元計測と２次元撮影とのカメラ座標の相対関係は既知であるので、形状データＤＳに基づく３次元形状モデルと２次元撮影像とを位置合わせすることは容易である。データ処理装置４０は図示しない画像処理回路を備えており、本発明に特有のデータ修正を含む各種のデータ処理を行う。すなわち、データ処理装置４０は本発明の第２の形状データを生成する手段であり、第１及び第２の形状データを合成する手段でもある。データ処理装置４０のコントローラ４２は、立体模型作成装置１の全体的な制御をも担い、撮影システム３０のコントローラ３８及び加工システム１Ｂのコントローラ７６に適切な指示を与える。このコントローラ４２には、ディスプレイ１６及び操作入力システム８０が接続されている。操作入力システム８０は、上述の操作パネル１８と料金受領機構とからなる。

【００１７】一方、加工システム１Ｂは、樹脂ブロックなどの材料を切削する加工装置７２、材料の加工位置への供給と加工品の取出口２０への搬送を行う材料供給装置７４、コントローラ７６、及び取出口センサ７８を備えている。取出口センサ７８の検出信号はコントローラ４２に入力される。なお、撮影システム３０及び加工システム１Ｂの制御をコントローラ４２に受け持たせ、コントローラ３８及びコントローラ７６を省略した回路構成を採用してもよい。

【００１８】図５は加工システム１Ｂの機構構成の一例を示す斜視図である。材料供給装置７４は、計８種の形状の材料を収納するストック部２１０を有している。収納空間は直線状の移送路２１２の両側に設けられ、各側の収納空間に移送路２１２に沿って４個ずつエレベータ２２０が配置されている。各エレベータ２２０に同一種類の複数個の材料が積み重ねられ、最上の材料が所定高さに位置するようにエレベータ２２０の上下移動制御が行われる。作成しようとする模型に適した一種類の材料が指定されると、指定された材料がワーク２１６として押出しロッド２１８によって収納空間から移送路２１２へ送り出される。そして、移送路２１２上のワーク２１６は、チャック付き移送ロッド２１４によって加工装置７２のテーブル２００に送り込まれる。

【００１９】テーブル２００において、ワーク２１６は２個のストッパ２０２とクランプ治具２０４とによって固定される。そして、上下・左右・前後に移動可能な回転軸２０６に取り付けられたエンドミルなどの刃物２０８によって切削される。

【００２０】３次元加工が終了すると、ワーク２１６は移送ロッド２１４の先端のチャックで挟持されて移送路２１２の排出側の端部へ運ばれ、排出口２２２に送り込まれる。移送ロッド２１４によらず、滑り台形式でワーク２１６をテーブル２００から排出口２２２へ移動させてもよい。

【００２１】加工システム１Ｂの機構構成は例示に限らない。例えば多段の各棚に同一種類の材料を水平方向に

並べ、その配列方向の一端にエレベータを配置し、棚からエレベータに材料を押し出すようにすれば、エレベータ数を低減することができる。アームロボットによってワークを収納位置→加工位置→排出位置へと運んでもよい。切削に代えて、積層造形法（光造形法を含む）、レーザー加工（熱加工）、成型加工（加圧など）などの手法で模型を作成することも可能である。また、材料形状については、利用客３が好みの外形を選択できるようにしてもよいし、予め標準的な顔の模型を作り込んだ複数種の材料から加工時間が最も短くなるものを自動選択するようにしてもよい。

【００２２】以上の構成の立体模型作成装置１においては、頭髪部の輪郭が正しく再現された自然な顔面模型を作成するため、３次元計測で得られた３次元形状モデルを自動的に変形するデータ修正がデータ処理装置４０によって行われる。すなわち、頭髪部のうちの有効な計測値の得られないデータ欠落箇所の形状が、複数の２次元画像に基づいて復元される。

【００２３】図６は２次元撮影のカメラ配置の模式図である。利用客３の立つ空間にＸＹＺ座標系を設定する。Ｘ軸を左右方向に、Ｙ軸を前後方向に、Ｚ軸を上下方向にとる。撮影位置は標準的な操作姿勢に合わせて定められ、図６においてＺ軸は利用客３の頭の中心軸と一致している。

【００２４】主カメラ３６及び補助カメラ３７Ａ，３７Ｂは、Ｚ軸周りに放射状に配置され、それぞれの視線（受光軸）はＺ軸上の１点（例えば座標原点）で交わる。主カメラ３６の視線はＹ軸と一致している。主カメラ３６に対する補助カメラ３７Ｌの視線の傾き角度θ１及び補助カメラ３７Ｒの視線の傾き角度θ２は同一である。ただし、必ずしも傾き角度θ１，θ２を同一にする必要はない。

【００２５】このようなカメラ配置において、主カメラ３６は利用客３を真正面から撮影し、補助カメラ３７Ｌは利用客３をその左斜め前方から撮影し、補助カメラ３７Ｒは利用客３をその右斜め前方から撮影する。なお、各視線を水平面に対して傾けてもよく、その傾き角度をカメラ毎に異なる値としてもよい。

【００２６】図７及び図８は２次元画像に基づくモデリングの要領を説明するための図である。データ処理装置４０は、まず、カラー画像データＤＣ１，ＤＣ２，ＤＣ３が表す２次元画像Ｇ１，Ｇ２，Ｇ３から図７で斜線の付された頭髪部分（頭髪像）ｈを抽出し、さらにその頭髪像ｈの輪郭を抽出する。頭髪像ｈの抽出の要領は次のとおりである。①特定の色空間（例えばＬ* ａ* ｂ* 色空間）においてクラスタリングを行うことにより、２次元画像を同色相の領域に分割する。②その結果に対してラベリングを行って同色相で且つ連続した領域を抽出する。③背景シート２の色（青）の領域に接しており、設定色相（例えば黒及びそれに近い色）の領域を頭髪像ｈとする。

【００２７】続いて、各２次元画像Ｇ１，Ｇ２，Ｇ３から抽出した頭髪像ｈのそれぞれの輪郭に対応した物体（利用客３）上の位置の３次元の相対関係を特定する。つまり、２次元画像Ｇ１，Ｇ２，Ｇ３又はそれらから抽出した頭髪像ｈを撮影条件に合わせて仮想的に３次元空間に配置したときの、頭髪像ｈの輪郭の座標を算定する。３次元空間への配置に際しては、図７で記号（＋）で示す画像の中心を一致させ、且つ互いの配置角度関係を撮影時の視線及び画角の向きの関係に対応させるとともに、物体の縮尺率が一致するように必要に応じて拡大し又は縮小する。画像の中心とは、撮影時の視線に対応した画素位置である。本実施形態では、撮影時の視線が同一平面内にあるので、各２次元画像Ｇ１，Ｇ２，Ｇ３をＺ軸に沿わせ、２次元画像Ｇ１に対して２次元画像Ｇ２，Ｇ３を角度θ１，θ２だけ傾けて配置すれば、画角の向きが揃うことになる。撮影倍率を同一に設定しておけば、拡大／縮小の必要はない。なお、頭髪像ｈの相対位置関係が判ればよいので、この段階で頭髪像ｈを物体に相応する大きさにする必要はない。図７（Ｂ）はＺ軸に垂直な１つの平面上での頭髪像ｈの輪郭の位置関係を示す平面図である。頭髪の外縁をモデル化する上で、Ｚ軸方向の注目位置における輪郭のＸ軸方向の位置のうち、両端の２点の位置が特に重要である。

【００２８】次に、仮想配置された計３つの頭髪像ｈの輪郭とＺ軸に垂直な面（等高面）で切断したときの交点をＢスプライン曲線で結び、頭髪の等高線Ｌｈを算出する。そして、Ｚ軸方向の複数の位置での等高線Ｌｈをスムージングで連結した面（サーフェス）を頭髪部分の形状モデルＵｈとする。

【００２９】図９は形状モデルの合成の模式図である。上述の要領で作成した頭髪部分の形状モデルＵｈと３次元計測で得られた利用客３の形状モデルＵｆとを３次元空間に位置合わせをして配置し、両者の和を求める集合演算を行って１個の形状モデルＵＭに合成する。このとき、頭髪部分の形状モデルＵｈは計測の欠落を復元する補助モデルとして扱い、重なりの矛盾が生じたときには原則として形状モデルＵｆを優先させてデータ修正を加える。

【００３０】このようにして得られた形状モデルＵＭを用いて加工を行うことにより、３次元計測において頭髪の一部のデータが得られなかったとしても、頭髪の概略を正しく再現した顔面模型を作成することができる。

【００３１】以下、フローチャートによって立体模型作成装置１の動作を説明する。図１０は概略の動作を示すメインフローチャートである。電源が投入された後、利用客による操作を待つ待機期間において、２次元撮影と撮影結果の表示とを繰り返す（＃１０、＃１２、＃１４）。また、定期的に案内メッセージを表示する。料金が投入されてスタートボタン１８１が押されると、改め

て２次元撮影を行うとともに３次元計測を行う（＃１６、＃１８）。所定のデータ処理を行い（＃２０）、得られた３次元形状モデルを表示する（＃２２）。このとき、影を付すといった公知のグラフィック手法を適用して見栄えを高める。そして、指示操作を待つ。ただし、待ち時間は有限であり、時限を過ぎれば確認操作が行われたものとみなす。

【００３２】ジョイスティック１８４が操作されると、上述のように３次元形状モデルを操作に応じて回転させて表示する（＃２４、＃３８）。キャンセルボタン１８３が押されると、待機期間の動作に戻る（＃４０、＃１０）。ただし、この場合、利用客が料金を改めて投入する必要はなく、スタートボタン１８１を押せば、再計測が行われる。

【００３３】確認ボタン１８２が押されると（＃２６）、３次元形状モデルに基づいて加工条件データベースを参照して加工制御用のデータを生成し（＃２８）。材料の加工を行う（＃３０）。加工が終わると、商品を排出し（＃３２）、取出口センサ７８によって商品が取り出されたのを確認して待機動作に戻る（＃３４、＃１０）。

【００３４】図１１は図１０のデータ処理の内容を示すフローチャートである。このルーチンでは、上述したように頭髪の形状を復元するデータ修正、及び加工時間の短縮やデザイン上の意図的な平面化のための奥行き方向の圧縮を含む次の処理が行われる。

【００３５】平滑化処理を行って、ノイズによる異常データを除くとともに、細かな凹凸まで過度に再現されるのを避ける（＃２００）。再標本化処理を行う（＃２１０）。これは、顔が斜めを向いていた場合などにおいて、入力データを加工方向に正対させるため、ある方向から平行投影した等間隔の格子点により整列されたデータに変換する処理である。例えば、人の顔の耳の下が陰になって測定できない場合、顔を上向きにして３次元測定をした後で、通常の正面を向いた顔を表すようにデータを変換できる。格子点が射影された位置に計測点がない場合には、その周囲の計測値により線形補完を行う。このとき、射影された方向が加工する際の鉛直上方となり、それぞれの格子点は、高さのデータを持つ。また、入力データが透視投影による場合でも、この処理により入力データを平行投影データに変換できる。

【００３６】データのない細かな欠損部分を補完する（＃２２０）。補完手法としては、線形補完、重み付け補完などの種々の手法が適用可能である。例えば、データの欠損している部分をすべて固定値で置き換える（単純補完）。その固定値としては、設定値、最小の高さ、顔の外周位置の平均値が考えられる。欠損部が有効データ部分で完全に囲まれている場合は、周りのデータから線形補完をする。これにより顔面内の欠損部分（例えば黒い眉）は復元される。

【００３７】上述した要領で頭髪部分の形状モデルＵｈを作成し、３次元の実測データに基づく形状モデルＵｆと合成する。つまり、形状モデルＵｆに対して、頭髪を付加する部分修正を行う（＃２３０）。この段階で頭髪部分に縞状の起伏を付加して質感を高めたり、目、黒目部分、眉、唇、頬などの特定部分を若干盛り上げる強調を行ったりすることができる。

【００３８】以上の各処理で実物形状に忠実な形状モデルＵＭを得た後、高さ圧縮処理を行って、３次元形状モデルの寸法を奥行き方向に縮める（＃２４０）。奥行き方向の高低差が小さくなれば加工時間が短くなる。また、ペンダントやメダルの用途では平面的な模型が好適である。圧縮には、一様圧縮及び非一様圧縮のどちらの手法も適用可能であり、部分毎に使い分けることもできる。

【００３９】３次元形状モデルのうちの背景部分を検出する（＃２５０）。これは背景部分を修正するための前処理である。背景シート３によって利用客の背面をブルーバックとしておけば、２次元画像の色判別によって背景部分を容易且つ確実に検出することができる。

【００４０】背景部分について他のデータに置き換える背景変換を行う（＃２６０）。例えば、背景部分は極端に奥行きが深いので、加工時間を短縮するために奥行きの浅いデータに変換する。置き換えるデータは、平面データでも花木などの絵柄や幾何模様を表す立体面データでもよい。

【００４１】実物大の３次元形状モデルを商品サイズに適合させるサイズ調整を行う（＃２７０）。また、加工装置７２の精度にデータ量を適合させる解像度変換を行う（＃２８０）。この処理は、所定格子幅のメッシュを投影して格子点で再標本化するものであるが、投影する方向は加工時の鉛直方向に固定されている。解像度変換（データ数変換）の要領としては、まず、加工用の形状モデルの構成点群を点間ピッチとベクトル変化量とで定義し、ベクトル変化量に対応する点間ピッチ範囲をあらかじめ記憶されている特性データテーブルから読み出して設定する。すなわち、データを間引いてピッチを大きくしたり、データを補間してピッチを小さくしたりする。計測の分解能が十分に大きい場合には、間引きのみを行えばよい。解像度変換機能を設けておけば、３次元計測装置３４の分解能が限定されないので、用途に応じて計測手段を取り換えるといった使用形態が許容されることになる。

【００４２】最後に、３次元形状モデルの基準位置が加工の基準位置に合うように座標の原点を平行移動させる位置合わせを行う（＃２９０）。なお、加工に際して上述のように予め所定の凹凸が作り込まれた材料を用いる場合には、確認操作に呼応した加工データ生成処理（図１０の＃２８）において、以上の処理によって得られた３次元形状モデルと作り込まれている凹凸とを比較して

切削量が算出される。

【００４３】図１２は図１１の部分修正サブルーチンのフローチャートである。図７で説明したように、まず、３方向の撮影情報である２次元画像Ｇ１，Ｇ２，Ｇ３を取り込み（＃３０１）、Ｌ* ａ* ｂ* 色空間における領域分割を行う（＃３０２）。設定色相の領域を頭髪像ｈと判別し（＃３０３）、その輪郭を抽出する（＃３０４）。頭髪像ｈの輪郭に対応した等高線Ｌｈを求め（＃３０５）、等高線Ｌｈを連結して頭髪の形状モデルＵｈを生成する（＃３０６）。そして、２次元画像に基づく頭髪の形状モデルＵｈと３次元計測に基づく形状モデルＵｆとを合成する（＃３０７）。

【００４４】以上の実施形態において、３次元計測データから頭皮面の形状を推定し、その結果を参照し、２次元画像から作成した形状が以下の要領で推定された頭皮面の内側にならないようにすることが望ましい。

【００４５】図１３は頭皮面形状の推定の模式図、図１４は頭皮面形状モデルの作成要領の一例を示すフローチャートである。顔領域Ｕｆ１と頭髪領域Ｕｆ２とからなる形状モデルＵｆから利用客３の頭部の輪郭を得る（＃３０５１）。輪郭上の複数個の適当な点（図１３の白丸）を選択し、選択した点又はそれらのうちの隣り合った点どうしの間の中点（図１３の黒丸）を制御点としてスプライン曲線で頭皮面形状を近似する（＃３０５２、＃３０５３）。顔領域Ｕｆ１については輪郭上の点を制御点とし、頭髪領域Ｕｆ２については中点を制御点とすることによって、頭髪の輪郭の内側を通る近似曲線を得る。同様の要領で複数の近似曲線を求め、それらの間をサーフェスで補間し、頭皮面形状モデルＵｓを得る（＃３０５４）。

【００４６】上述の実施形態では、自動販売機としての使用を想定した立体模型作成装置１を例示したが、本発明に係るデータ処理は模型作成が有償であるか無償であるかを問わない。模型のサイズは縮小サイズに限らず、実物大でも拡大サイズでもよい。複数の２次元画像に基づく形状モデルＵｈと３次元計測データに基づく形状モデルＵｆとの合成で得られた形状モデルＵＭは、表示やアニメーション作成など模型作成以外の種々に用途に用いることができる。

【００４７】

【発明の効果】請求項１又は請求項２の発明によれば、人体の頭髪形状のように３次元計測が困難な部分を有した物体の形状のモデル化を実現することができる。

【図面の簡単な説明】

【図１】本発明に係る立体模型作成装置の外観図である。

【図２】立体模型作成装置の使用状態の模式図である。

【図３】操作パネルの平面図である。

【図４】立体模型作成装置の機能ブロック図である。

【図５】加工システムの機構構成の一例を示す斜視図である。

【図６】２次元撮影のカメラ配置の模式図である。

【図７】２次元画像に基づくモデリングの要領を説明するための図である。

【図８】２次元画像に基づくモデリングの要領を説明するための図である。

【図９】形状モデルの合成の模式図である。

【図１０】概略の動作を示すメインフローチャートである。

【図１１】図１０のデータ処理の内容を示すフローチャートである。

【図１２】図１１の部分修正サブルーチンのフローチャートである。

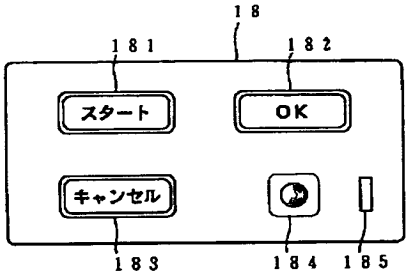
【図１３】頭皮面形状の推定の模式図である。

【図１４】頭皮面形状モデルの作成要領の一例を示すフローチャートである。

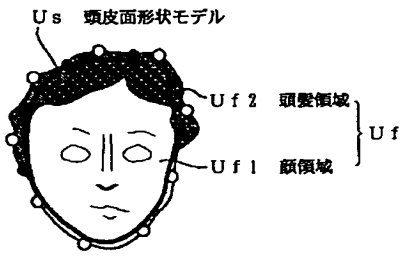
【符号の説明】

１Ａ　モデリングシステム
３　利用客（物体）
３０　撮影システム
３４　３次元計測装置（３次元測定装置）
４０　データ処理装置
Ｇ１～３　２次元画像
Ｕｆ　形状モデル（第１の形状データ）
Ｕｈ　形状モデル（第２の形状データ）

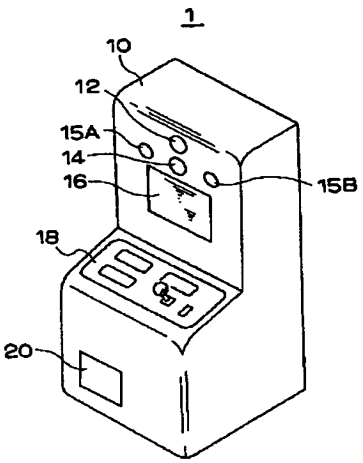
【図３】



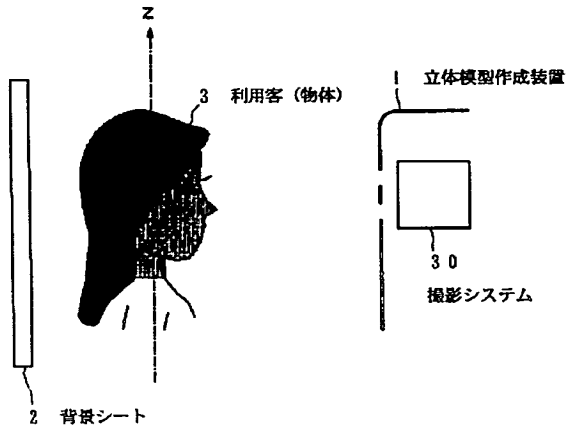
【図１３】



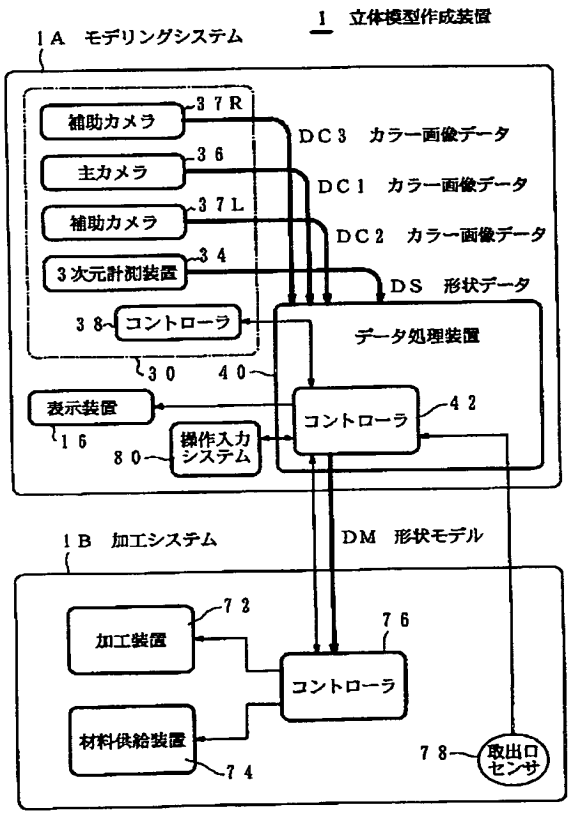
【図１】


1
10
12
15A
14
16
15B
18
20

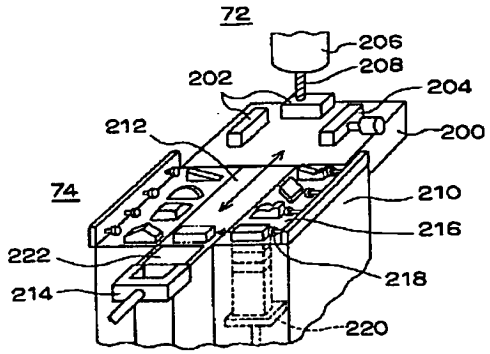
【図２】


Z
3　利用客（物体）
立体模型作成装置
30
撮影システム
2　背景シート

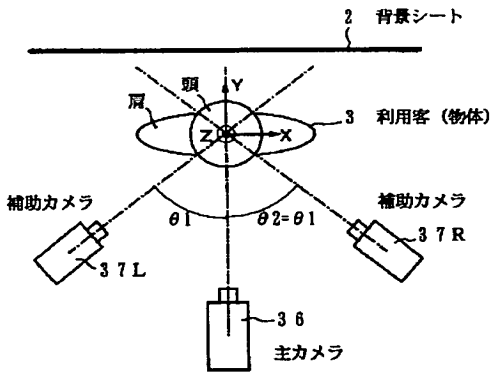
【図４】


1　立体模型作成装置
1A　モデリングシステム
補助カメラ
37R
DC3　カラー画像データ
主カメラ
36
DC1　カラー画像データ
補助カメラ
37L
DC2　カラー画像データ
3次元計測装置
34
DS　形状データ
38
コントローラ
データ処理装置
30
40
表示装置
16
操作入力システム
80
コントローラ
42
1B　加工システム
DM　形状モデル
加工装置
72
76
コントローラ
材料供給装置
74
78
取出口センサ

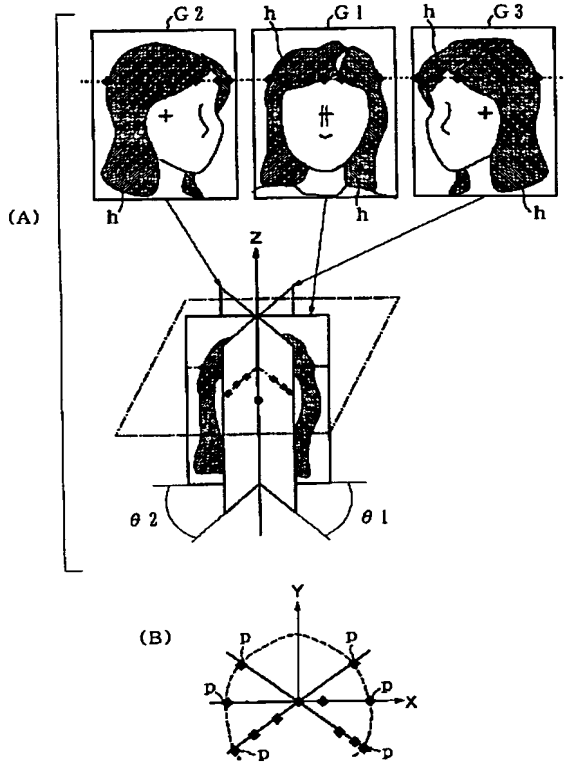
【図５】


72
206
208
202
204
212
200
74
210
216
222
218
214
220

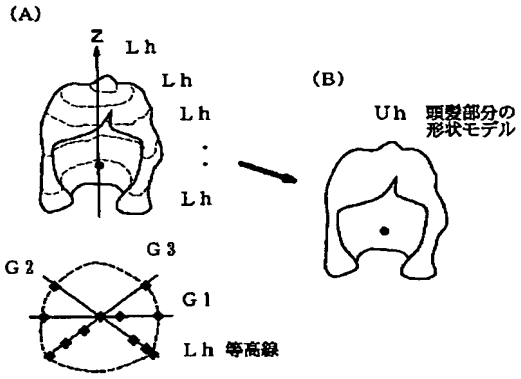
【図６】


2　背景シート
頭
Y
肩
3　利用客（物体）
Z
X
補助カメラ
θ1
θ2=θ1
補助カメラ
37R
37L
36
主カメラ

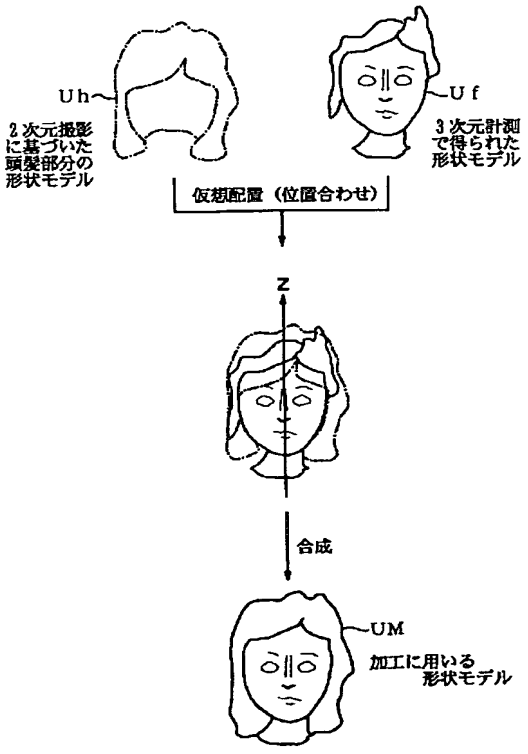
【図7】


(A)
G2
h
G1
h
G3
h
h
h
Z
θ2
θ1
(B)
Y
X
p
p
p
p
p
p

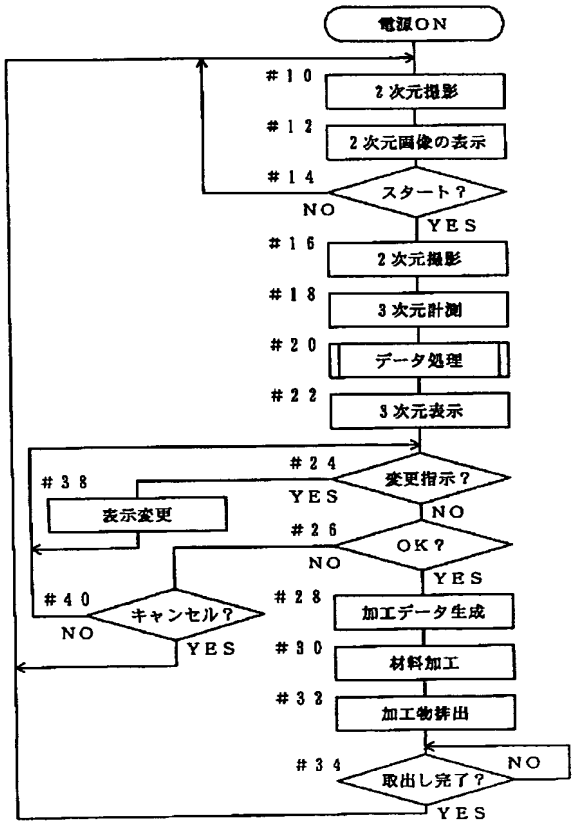
【図8】


(A)
Z
Lh
Lh
Lh
Lh
G2
G3
G1
Lh 等高線
(B)
Uh 頭髪部分の
形状モデル

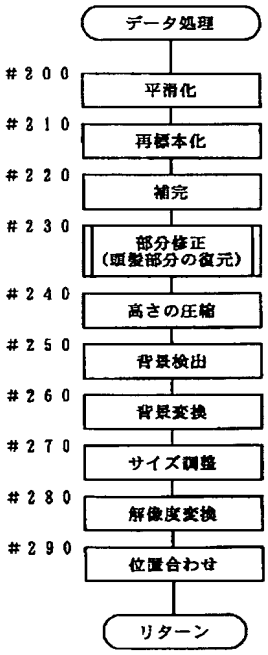
【図9】


Uh
2次元撮影
に基づいた
頭髪部分の
形状モデル
Uf
3次元計測
で得られた
形状モデル
仮想配置（位置合わせ）
Z
合成
UM
加工に用いる
形状モデル

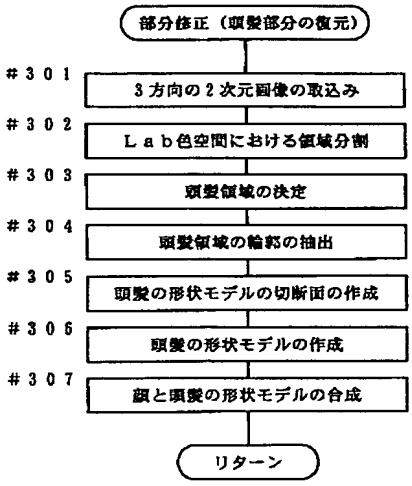
【図10】


電源ON
#10
2次元撮影
#12
2次元画像の表示
#14
スタート？
NO
YES
#16
2次元撮影
#18
3次元計測
#20
データ処理
#22
3次元表示
#24
変更指示？
YES
NO
#38
表示変更
#26
OK？
NO
YES
#40
キャンセル？
NO
YES
#28
加工データ生成
#30
材料加工
#32
加工物排出
#34
取出し完了？
NO
YES

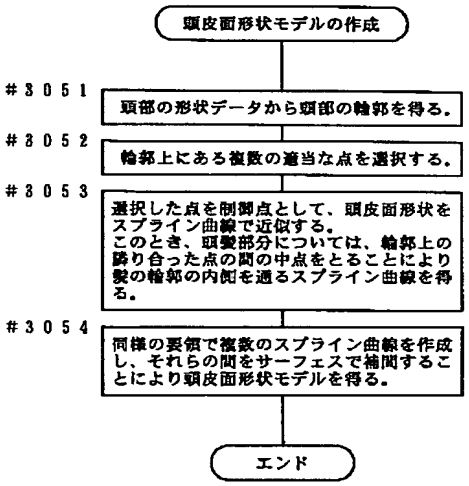
【図１１】


データ処理
＃２００
平滑化
＃２１０
再標本化
＃２２０
補完
＃２３０
部分修正
（頭髪部分の復元）
＃２４０
高さの圧縮
＃２５０
背景検出
＃２６０
背景変換
＃２７０
サイズ調整
＃２８０
解像度変換
＃２９０
位置合わせ
リターン

【図１２】


部分修正（頭髪部分の復元）
＃３０１
３方向の２次元画像の取込み
＃３０２
Ｌａｂ色空間における領域分割
＃３０３
頭髪領域の決定
＃３０４
頭髪領域の輪郭の抽出
＃３０５
頭髪の形状モデルの切断面の作成
＃３０６
頭髪の形状モデルの作成
＃３０７
顔と頭髪の形状モデルの合成
リターン

【図１４】


頭皮面形状モデルの作成
＃３０５１
頭部の形状データから頭部の輪郭を得る。
＃３０５２
輪郭上にある複数の適当な点を選択する。
＃３０５３
選択した点を制御点として、頭皮面形状をスプライン曲線で近似する。
このとき、頭髪部分については、輪郭上の誇り合った点の間の中点をとることにより髪の輪郭の内側を通るスプライン曲線を得る。
＃３０５４
同様の要領で複数のスプライン曲線を作成し、それらの間をサーフェスで補間することにより頭皮面形状モデルを得る。
エンド